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Neuropsychological Assessment of Executive Functioning and Its Association with Depressive Symptomology

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NEUROPSYCHOLOGICAL ASSESSMENT OF EXECUTIVE FUNCTIONING AND ITS ASSOCIATION WITH DEPRESSIVE SYMPTOMOLOGY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The current study explored the construct of executive functioning and neuropsychological measurement techniques used to assess executive functioning (EF). Two current comprehensive measures of executive functioning include the Behavior Rating Inventory of Executive Functioning-Adult Version (BRIEF-A) and the Delis-Kaplan Executive Functioning System (D-KEFS). The BRIEF-A is a self-report questionnaire that reportedly assesses behaviors associated with EF, and the D-KEFS is a battery of tests that are objectively administered by a trained examiner to directly measure different manifestations of EF ability. This study examined the relationship between gender and general intellectual ability on EF and investigated each measure's construct validity in assessing EF in the context of symptoms of depression. The factor structures of these measures of EF were assessed using confirmatory factor analytic statistical techniques to determine their convergent validity in measuring EF domains in a college sample. A three-factor model for the BRIEF-A and a five-factor model solution for the D-KEFS emerged as the best fitting models for each measure. Overall, these results have implications for the neuropsychological assessment of EF, and in particular for assessing EF in clients experiencing depressive symptomology.

CHAPTER ONE

INTRODUCTION

Executive functioning is a term used to describe higher-ordered cognitive processes, such as creative thinking, problem solving and planning behavior (Zelazo & Frye, 1998). Executive functioning has received a tremendous amount of attention in the past decade, conceivably because of its importance to everyday human functioning and the significant impairments that ensue for individuals with executive dysfunction. To illustrate, a recent meta-analysis by Alvarez and Emory (2006) indicated that over 2500 scientific articles had been published in the past decade on executive functioning. Despite the explosion in this new line of research, there are still inconsistencies in definition and measurement. This is most likely due to the effect of ambiguities in how to define executive functioning (Denckla, 1994) as well as substantial variability in the measurement of executive functioning by psychologists (Alvarez & Emory, 2006). For example, a survey of commonly used tests among 250 members of the International Neuropsychological Society resulted in thirteen different assessments of executive functioning (Butler, Retzlaff, & Vanderploeg, 1991), highlighting the need for consensus on the description of these cognitive abilities to enable psychologists the capacity to accurately assess and treat patients.

One definition of executive functioning in the academic literature is the set of cognitive abilities involved in purposeful, goal directed behavior (Barkley, 1997, 2001;

Welsh, Pennington, & Grossier, 1991). Many researchers have discussed executive functioning in terms of some of its individual components, namely working memory (Barkley, 2001), attention (Rueda, Posner, & Rothbart, 2005), behavioral regulation (Barkley 1997, 2001; Brocki & Bohlin, 2004), and set-shifting/inhibition (Baddeley, Chincotta, & Adlam, 2001). These components have been identified mainly because of their associations with the frontal regions of the brain. Individuals that have disorders or conditions that negatively affect their frontal lobes often demonstrate significant deficits in performance on tasks measuring these components (Stuss & Benton, 1984). For example, individuals with attention deficit hyperactivity disorder (i.e., ADHD) have greater difficulty on tasks of attention (Stins, Tolenaar, Slaats-Willemse, Buitelaar, Swaab-Barneveld, Verhulst, Polderman, & Boomsma, 2005).

However, in addition to the cognitive aspect of executive functioning, researchers and practitioners also recognize an observable behavioral component to executive functioning. Problem solving, planning, and organization skills are often suggested as outward behavioral aspects of executive functioning (Brocki & Bohlin, 2004; Gioia, Isquith, Guy, & Kenworthy, 2000). These areas have received far less attention in the literature due to the lack of assessment for "real world" behaviors outside of the laboratory. However, as scientist-practitioners, clinical psychologists recognize the need for multi-modal assessments across a number of situations. The addition of a self-report measure, the Behavior Rating Inventory of Executive Function (BRIEF; Gioia & Isquith, 2004), has allowed greater attention toward the behavioral manifestations of executive functioning. Despite the introduction of behavioral assessments like the BRIEF, further research is necessary to determine the utility of self-report questionnaires in the measurement of executive functioning.

While a consensus on the definition and measurement of executive functioning is primary, consideration also needs to be given to the effects of physical and mental conditions on assessment. Neuropsychological assessment purports to assess the functioning of individuals in response to specific referral questions, often related to psychiatric or neurological disorder (e.g., ADHD, epilepsy, stroke, etc). However, other psychiatric disorders, such as depression, can interfere with the validity of these assessments, affecting their viability in assessing what they intend to measure (e.g., executive functioning; Channon, 1996). Given the representation of depression in the population, a disorder affecting one out of ten people, it is not unlikely that the patients in need of assessment may suffer from depression (Elliot, 1998). In addition, depression is often co-morbid with other physical and psychiatric illnesses (Schmitz, Wang, Malla, & Lesage, 2007).

It is also known that depression affects performance on standardized assessments of general cognitive ability and executive functioning (Elliot, 1998; Goodwin, 1997; Hartlage, Alloy, Vazquez, & Dykman, 1993; Walter, Wolf, Spitzer, & Vasic, 2007). In particular, depressed patients tend to show psychomotor slowing and suppressed performance on tests requiring frontal lobe involvement (Veiel, 1997). However, it is less clear how depression or depressive symptomology may differentially affect traditional, examiner-administered assessment approaches versus self-report behavior questionnaires in regard to executive functioning.

The current study assessed two neuropsychological assessments that claim to measure a comprehensive construct of executive functioning. The main goal of this study was to assess the viability of these assessment tools for the measurement of executive functioning and their sensitivity to symptoms of depression. The following section presents a review of the literature. Given the ambiguity in the literature on a definition of executive functioning, research related to this topic are reviewed to provide a description of executive functioning as it pertained to this study. The assessments used to measure executive functioning are provided next, followed by a discussion of the association of depression/depressive symptomology with assessment.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Executive Functioning Definition

Executive functioning has been defined as higher-ordered thinking that involves self-directed, goal-oriented behavior (Lezak, 1982; Nauta, 1971). Divergent from general cognitive ability or intelligence, executive functioning implies engagement in creative thought, having open-mindedness towards new solutions as well as appropriate self-regulatory skills (Delis, Lansing, Houston, Wetter, Han, Jacobson, Holdnack, & Kramer, 2007; Welsh, Pennington, & Grossier, 1991). Thus, executive functioning can be considered an important aspect of human experience that may have allowed humans to adapt to changing situations and come up with novel solutions to encountered problems (Barkley, 2001).

Whereas general cognitive ability involves the acquisition of information, executive functioning represents what people do with that information and how they do it (Lezak, 1982). For example, devising a novel solution to a problem (executive function ability) requires the use of one's already acquired knowledge (general cognitive ability) in order to brain-storm possible solutions, plan out the solution, and execute the plan (Stuss, 1992). Although individuals typically use basic skill sets to engage in higher ordered thinking, there is not necessarily a one-to-one relationship between basic and higher ordered cognition. Recent research suggests that individuals may have neuropsychological profiles in which their executive functioning ability is significantly discrepant from their general intellectual ability (Delis et al, 2007). Whereas some individuals have higher relative executive functioning, others may have lower relative executive functioning compared to their general intellectual ability, indicating that executive functions and general cognitive ability are not synonymous with each other. Further evidence for the divergence between general cognitive ability and executive functioning is illustrated in previous research with patients who have suffered frontal lobe damage; these patients often have relatively spared general cognitive abilities but show profound deficits in executive functioning (Lezak, Howieson, & Loring, 2004; Welsh, Pennington, & Grossier, 1991).

Although executive functioning may overlap with general cognitive ability, it is arguable that it should be considered a separate cognitive domain of its own (Denckla, 1994). Greater understanding of the executive functions is warranted. Executive functioning, as a domain, has both neuroanatomical and psychodevelopmental delineations. The development of executive functioning is progressive, beginning in infancy and continuing into early adulthood (Welsh, Pennington & Grossier, 1991; Barkley, 2001; Ylvisaker & Feeney, 2002). This development is thought to mirror the development of the frontal lobes, so it naturally proceeds, from a neuroanatomical viewpoint, that the cognitive processes involved in executive functioning have been associated with the frontal lobes (Brocki & Bohlin, 2004; Casey, Giedd, & Thomas, 2000; Denckla, 1994; Tranel, Anderson, & Benton, 1994; Welsh, Pennington & Grossier, 1991). As the frontal lobes develop with increasing age, individuals become adept at progressively more complex cognitive abilities (Denckla, 1994). Thus, the progression of executive functioning is noteworthy in that the acquisition of cognitive skills aids in the development of subsequent cognitive skills. For example, one theory posits that behavioral inhibition allows for engagement in mental activity, such as working memory (Barkley, 1997; 2001). Neuropsychological data supports the basis of such theories; successful performance on executive functioning tasks is often dependent on successfully developed ability on basic or simpler tasks (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Kramer, et al, 2007).

Since executive functioning has only recently been recognized as a separate domain of abilities, the developmental literature has been most helpful in identifying individual components that comprise cognitive functioning (Denckla, 1994). For example, there is a large literature base that includes research using tasks of planning and attention (Brocki & Bohlin, 2004; Zelazo & Frye, 1998). However, there has been a large amount of variability in the skills identified as executive functions. This may be partially attributed to the tendency for the same ability to be called different names in the literature (e.g., “switching” and “set-shifting”). In addition, this may also be because it is difficult to identify each individual component of executive functioning. For example, the literature suggests that the individual components of executive functioning, once developed, work together to accomplish self-directed, purposeful actions, which makes it difficult to tease each component apart (Barkley, 2001; Denckla, 1996).

Because of the inter-relatedness among executive functions, there has been some debate in the literature as to whether executive functions constitute a unitary or multi-faceted construct (Denckla, 1994; 1996; Gioia, Isquith, Retzlaff, & Epsy, 2002). From a unitary domain standpoint, executive functions serve to carry out goal directed behaviors with the components of executive functioning working together to achieve this goal (Gioia et al, 2002). These individual components may be difficult for researchers to identify and measure because of their close relationship to each other. For example, by engaging in one task an individual is by definition disengaging from another. From this viewpoint, the two skills of engaging and disengaging are inextricably tied and difficult to separate from one another; they may be more readily identified by the end product (e.g., task completion).

While there is an argument towards viewing executive functions as a unity domain, many other researchers argue that the term executive functioning represents a domain of separate processes (Denckla, 1994; 1996; Gioia et al, 2002). They maintain that while components of executive functioning may relate to one another, they represent separate, identifiable abilities. The neuroanatomical literature has helped to clarify this position; much of the literature supporting this multi-faceted view of executive functioning comes from observations of patients with frontal lobe damage. For example, Salloway (1994) found similar presentations in patients with frontal system dysfunction referred to an inpatient neuropsychiatry service over a year. He reported that these patients typically presented as apathetic, disorganized, and/or disinhibited. Nauta (1971) identified what seemed to be somewhat polar characteristics of frontal lobe patients. He noted that patients tended to demonstrate either euphoric or apathetic mood changes, which although quite opposite in nature, are identifiable aspects of frontal lobe damage.

He also reported that frontal lobe patients showed polar types of behavioral changes, such as lack of initiation and perseveration.

Denckla (1996) refers to the behavioral components (e.g., inhibition, delayed responding, set maintenance) as the "control processes" of executive functioning because of their relationship to motor processes and behavioral output. Similarly, Barkley (1997) argues that the behavioral aspects of executive functioning represent a separate component of the domain. He elaborates that behavioral inhibition, in particular, is central to other executive functions in that it allows for sustained mental attention to occur.

Sustained mental activities represent additional aspects of executive functioning in multi-dimensional models. It is hypothesized that these mental activities include such skills as abstract reasoning, planning, sequential processing, and problem solving (Denckla, 1996; Barkley, 2001). These "meta-cognitive" components within the domain of executive functioning represent what occurs in the period of time between delay and response, or during mental activity (Denckla, 1996) and are most often identified on cognitive tasks within the developmental literature (e.g., problem solving).

Although traditional models of executive functioning tend to view the term as encompassing a set of inter-related, but separate processes rather than a unitary process, it is still unclear what specific processes define executive functioning. Since the processes involved with executive functioning are often inter-related, it may be difficult to distinguish executive functioning abilities from one another (Denckla, 1996). Furthermore, there is often a lack of consensus on definitions of individual components of executive functioning (Denckla, 1994). For example, in their respective "definitions," the neuroanatomical literature identifies patterns of behavior often observed in patients with frontal lobe damage and the developmental literature identifies performance on meta-cognitive tasks; though these bodies of research may represent convergent constructs, they typically have developed in isolation of each other. The following sections present an overview of the components of executive functioning from both developmental and neuroanatomical lines of research.

Components of Executive Functioning

There has been a surge of research, particularly in the past decade, investigating aspects of executive functioning. However, as presented in the previous section, there is a great deal of overlap among the executive functions. As the purpose of this study is to identify common aspects of executive functioning within neuropsychological assessment and not to debate differences found within the literature (e.g., between developmental and neuroanatomical literature bases), this section will serve as a discussion of frequently identified components of executive functioning in the literature. These executive functions include: behavioral inhibition, attention, self-regulation, set-shifting, abstract reasoning/problem solving, and working memory.

Behavioral inhibition is frequently identified in both neuropsychological and developmental research (Denckla, 1994). In addition to being described as an important precursor to other executive functions, is also one of the earliest executive functions to emerge (Barkley, 2001; Brocki & Bohlin, 2004). This ability to delay an immediately gratifying behavior emerges in early infancy and during the first few months of life. It is during these early years that infants also become better able to regulate their emotions and control their behavior. However, although behavioral inhibition emerges early in development, major developmental advances occur between seven and 12 years of age (Brocki & Bohlin, 2004), which highlights the gradual progression of executive functioning through childhood and into adolescence. Behavioral inhibition can be an observable component of executive functioning, especially to caregivers and educators working with children at different developmental stages (Denckla, 1996). For example, a young child has great difficulty controlling his/her impulses and will require adult reminders as to what behaviors are appropriate. On the other hand, an adolescent is more capable of inhibiting his/her behavior; such as deciding not tell his/her friend an amusing story during class when the teacher is talking. The successful development of behavioral inhibition is evidenced by an individual’s ability to control an initial response in the face of competing demands, and engage in a self-directed action (Barkley, 1997).

Closely related to behavioral inhibition is attention, because as one behavior is being inhibited, another behavior is inherently being attended to (Denckla, 1994). This is elaborated in Posner’s model of attention, which suggests that attention develops from a reactive to a controlled response. Within this model, infants are initially reactive to stimuli in their environment; their attention to external stimuli works to regulate their internal distress through alerting and orienting responses (Rueda, Posner, Rothbart, 2005). As they continue to develop this reactive response, they are able to shift their attention to external stimuli and orient towards it (Rueda, Fan, Candliss, Halparin, Gruber, & Pappert, 2004). This basic attention is a precursor to a more sophisticated, controlled attention which is characteristic of the processes in executive functioning.

As self-regulation (i.e., regulating internal distress) improves, children progress from a reactive type of attention towards volitional or goal-oriented attention (Rueda, Posner, Rothbart, 2005). Children begin to attend to stimuli not because it is distressing, but because it may be new and interesting. An example of this developmental progression in the literature is the AB task, where children must find a toy after seeing it hidden behind one screen, and then after several trials, they must find the toy after they see it hidden behind a new screen. Prior to the age of two, children will continue to search for the toy behind the first screen because they are unable to disengage their attention from the first screen (Zelazo & Frye, 1998). However, after the age of two children are able to search for the toy behind the new screen, indicating that they are better able to regulate their internal learned response (e.g., search behind the first screen), to engage in the new, planned behavior.

This goal-directed attention continues to develop through adolescence (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Casey, Trainor, Orendi, Schubert, Nystrom, & Giedd, 1997). Frequently, individuals who are better able to withhold one response in order to engage in another are considered to be more “flexible” in their thinking (Zelazo & Frye, 1998). This hallmark aspect of executive functioning has been cited as “set-shifting” in the neuropsychological literature. As behavioral inhibition and self-regulation improves, children are better able to direct or “shift” their attention across tasks and engage in cognitively stimulating activities (Zelazo & Frye, 1998). Similarly, in adults, set-shifting allows for the ability to alternate between different response sets (Baddeley, Chincotta, & Adlam, 2001; Wecker et al, 2005).

The uniqueness of executive functions is within this dual process of behavioral control and cognition. As previously stated, executive functioning is the result of an integration of multiple mental functions, which once developed, work with fluidity to accomplish the goal of self-guided behavior in the individual (Barkley, 2001). While one must have acquired the basic motor skills necessary for the behaviors previously described in orienting, alerting, and attending, the executive component of these motor skills involves the voluntary inhibiting of behaviors to engage in self-directed behaviors. Once individuals are more adept at the behavioral regulation component of executive functioning (i.e., they can sufficiently self-regulate their emotions, inhibit their behaviors and delay their responding), it is thought that they are able to more efficiently engage in the cognitive aspects of executive functioning (Barkley, 1997; Denckla, 1996).

Individuals are able to better mentally work through problems and figure out solutions to tasks as they gain the ability to think about past experiences as well as a hypothetical future (Barkley, 2001). The executive functioning ability to internally represent information is termed working memory. Different from the ability to recall past events, working memory involves the ability to manipulate mental activity, to integrate the past with current perceptions while keeping an eye on the future (Barkley, 2001; Denckla, 1996). As such, working memory is like a type of on-line mental system, where an individual holds information just received in his/her head so that it may be used for a subsequent task (e.g., hearing a list of numbers, mentally sequencing them, and repeating them back in sequence).

Working memory aids in the ability to engage in more complex thought. An "internal dialogue" develops that allows one to work through tasks without external direction (Barkley, 1997). Effective working memory entails an "awareness of the activity of the mind" (Denckla, 1996), an introspection into the working of one's thoughts. As working memory improves, an individual is able to work through problems internally, considering possible solutions until the decision is made to engage. This internal "trial and error" is much more efficient than actually trying out every solution until the correct one is found, which can be impractical and time consuming.

Working memory has been frequently studied in the literature, and as such, has been theoretically fractioned into component parts (Baddeley, Chincotta, & Adlam, 2001; Smith & Jonides, 1998). Baddeley and Hitch (1974) proposed a three component model of working memory, consisting of a "phonological loop," the "visuospatial sketchpad," and the "central executive." The central executive has been described as the ability to divide attention between two simultaneous tasks or set-shifting, which was previously discussed (Baddeley, Chincotta, & Adlam, 2001; Wecker et al, 2005). Evidence suggests that the central executive or set-shifting aspect of working memory is affected in individuals with frontal lobe lesions (Baddeley, Della Sala, Papagno, & Spinnler, 1997). In addition, working memory has also been fractioned into verbal and non-verbal (or spatial) components (Smith & Jonides, 1998). The verbal component is known as the "phonological loop," and the non-verbal component is labeled the "visuospatial sketchpad." This verbal/non-verbal component distinction has been supported by neuroimaging studies with verbal and non-verbal working memory tasks indicating that different brain regions are involved in the processing of each task (Smith & Jonides, 1998). The neuroanatomical distinctions of executive functioning are explored further in the next section.

Neuroanatomical Correlates of Executive Functioning

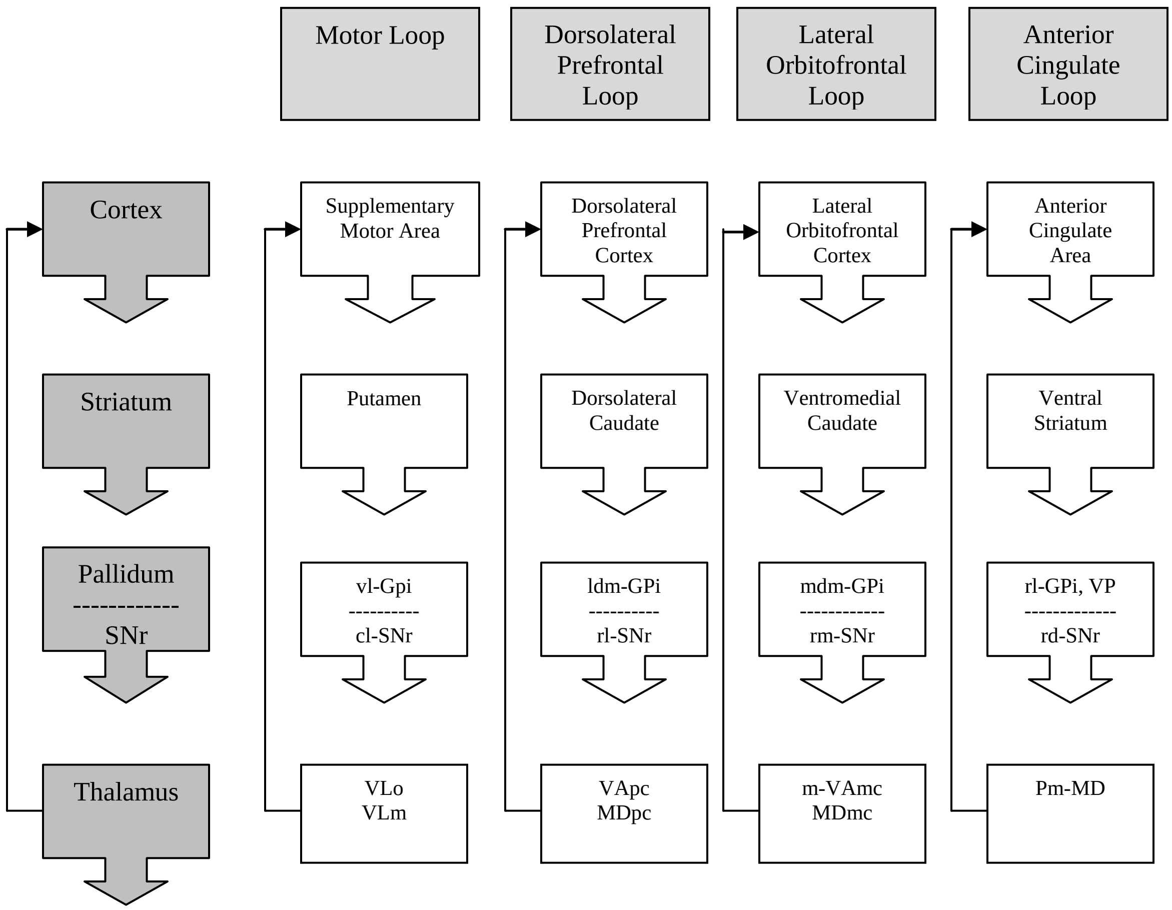
Employment of the executive functions has been generally associated with the prefrontal regions of the brain (Barkley, 1997; Brocki & Bohlin, 2004; Casey, Giedd, & Thomas, 2000; Stuss, 1992; Tranel, Anderson, & Benton, 1994; Welsh, Pennington & Grossier, 1991), thus executive functioning and frontal lobe functioning have become interchangeable terms in the literature (Denckla, 1996; Tranel, Anderson, & Benton, 1995). While accurate, this delineation is grossly simplistic considering the complexity of the executive functions and recent evidence implicating other brain regions involved in executive functioning (Denckla, 1996). Yet, equating the frontal lobes and executive functioning has made for a useful starting point, and as will be explored next, has allowed for further investigation of the neuroanatomy of executive functioning.

The identification of the executive functions arose from clinical work with patients experiencing difficulties within specific domains; therefore the delineation of executive functioning became rooted in neuroanatomy (Denckla, 1996). The earliest and most recognized example is that of Phineas Gage, who sustained an injury to his frontal lobes and as a result suffered significant changes in his personality. Since that time, work with patients with frontal lobe lesions or patients with disorders affecting the frontal lobes has similarly found an association between the constructs of executive functioning and impairment in the frontal lobes (Nauta, 1971; Stuss & Benton, 1984).

Brain injury studies provide further validation for the frontal lobes and associated brain regions involved with executive functioning. While patients with cognitive deficits typically show impairments that can be localized to specific brain areas, patients who demonstrate impairments in executive functioning tend to show more global deficits (Nauta, 1971; Malloy, Webster, & Russell, 1985), suggesting that executive functions are associated with frontal circuitry in the brain rather than a localized brain area. The frontal lobes have vast neural connections with other brain regions outside of the frontal lobes (Stuss & Benson, 1984), which greatly expands the areas that may be involved in the executive functions. For example, patients with damage to frontal-subcortical white matter circuits often show deficits in executive functioning (Denckla, 1996). Furthermore, the prefrontal cortex integrates information from other brain regions, such as parietal and temporal regions of the central cortex and the limbic system (Nauta, 1971); breakdowns occurring at multiple points along frontal pathways could result in executive functioning impairments.

There are four neural networks with frontal lobe connectivity that are typically identified in the literature: motor, dorsolateral prefrontal, lateral orbitofrontal and anterior cingulate (see Figure 1; Chudasama & Robbins, 2006; Goodwin, 1997). These “frontal loops” relay information from a specific region in the frontal cortex, through a level in the striatum, and back to the frontal cortex via the thalamus. When a breakdown occurs in the frontal circuitry, subsequent breakdowns occur in the frontal association areas,

Figure 1. Neural networks with frontal connectivity.



Note: Adapted from Chudasama & Robbins (2006) resulting in impairments within several domains (Wolfe, Linn, Babikian, Knoeffel et al, 2004). As a result, patients with executive dysfunction may neuropsychologically appear more severely impaired than they actually are. For example, individuals with frontal lobe damage can have impairments in their ability to know *how* to respond (e.g., plan out a strategy), which consequently can result in their inability to know *what* to correctly respond (Lezak, Howieson, & Loring, 2004).

The dorsolateral prefrontal region is most often implicated in the operation of the executive functions (Barkley, 1997; Brocki & Bohlin, 2004; Dennis, 1991; Casey, Giedd, & Thomas, 2000; Stuss, 1992; Tranel, Anderson, & Benton, 1994; Welsh, Pennington & Grossier, 1991). Neuroimaging studies have consistently found that the dorsolateral prefrontal cortex is involved with executive functioning tasks, namely those involving working memory (Conklin et al, 2007; Haut, Kuwabara, Leach, & Arias, 2000; Smith & Jonides, 1998; Walter, Wolf, Spitzer, & Vasic, 2007; Wendelken, Bunge, & Carter, 2008) and verbal fluency (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Lezak, 1982; Malloy, Cohen, Jenkins, & Paul, 2006; Veiel, 1997).

Several studies have found increased activation in the dorsolateral prefrontal cortex with performance on fluency tasks (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Lezak, 1982; Malloy, Cohen, Jenkins, & Paul, 2006; Veiel, 1997). Verbal fluency tasks are typically considered tasks of executive functioning because they intend to measure verbal generation as well as a patient's ability to organize information into meaningful categories (e.g., phonological or semantic clusters; Lezak, 1982). Imaging studies indicate that the left dorsolateral prefrontal cortex is specifically involved in verbal fluency tasks (Veiel, 1997). In contrast, design fluency tasks, which are the non-verbal or visual analogues to verbal fluency tasks, were initially thought to be more sensitive to right frontal lesions (Malloy et al, 2006). However, recent evidence suggests that patients with right and left frontal lesions perform equally poor on a design fluency task, suggesting that for non-verbal fluency tasks there may be bilateral frontal involvement (Baldo et al, 2001).

Similarly, several studies have suggested lateralized processing in the dorsolateral prefrontal cortex with working memory performance (Haut et al, 2000; Smith & Jonides, 1998). In particular, the right dorsolateral prefrontal cortex appears to process visual and spatial aspects of working memory, whereas the left dorsolateral prefrontal cortex seems to process verbal working memory (Smith & Jonides, 1998). However, some findings indicate activation in the right dorsolateral prefrontal cortex for a letter-number sequencing task, indicating that individuals may visualize verbal information in order to effectively perform the task (Haut et al, 2000).

Despite the strong implication of the dorsolateral prefrontal cortex in working memory tasks, several studies have found activation in additional brain regions, such as the orbital frontal lobe, posterior parietal cortex (Haut et al, 2000; Wendelken, Bunge, & Carter, 2008), and occipital cortex (Smith & Jonides, 1998). Similarly, a recent fMRI study found that the medial dorsal frontal and the parietal cortex were both engaged during a visual set-shifting task (Slagter, Giesbrecht, Kok, Weissman, Kenemans, Woldroff, & Mangun, 2007). There are several plausible explanations for these discrepant findings. It is possible that tasks that are considered to primarily invoke dorsolateral prefrontal processing may also incorporate processing in other frontal striatal circuits in addition to the dorsolateral prefrontal loop. For example, many assessments of executive functioning may tap into additional skill sets, such as visual or motor abilities (Denckla, 1996). Patients with frontal and non-frontal lesions have also been reported to demonstrate poor performance on executive functioning tasks that involve these additional skill sets (e.g., Wisconsin Card Sorting Test, Category Test, and Trail Making Test; Malloy et al, 2006). Thus, it is possible that mixed neuroanatomical findings may reflect impurities in measurement, and this inherent issue in the assessment of executive functioning will be explored in greater detail in the following section. However, germane to the current discussion, these results lend support to the employment of additional regions outside of the dorsolateral prefrontal cortex in executive functioning.

There is further evidence in the literature for the involvement of additional frontal circuits in executive functioning depending on task complexity. Some neuroimaging studies suggest that the role of the dorsolateral prefrontal cortex in working memory may be dependent on task load. For example, the dorsolateral prefrontal region has been implicated in the manipulation aspect of working memory whereas the ventrolateral prefrontal cortex has been implicated with the maintenance of information (over delayed period) in working memory (Conklin et al, 2007; D’Esposito, Aguirre, Zarahn, Ballard, Shin, & Lease, 1998). These findings point to a process-specific model for executive functions. Within this model, different processes within a domain of executive functioning have different neurobiological correlates (D’Esposito et al, 1998; Smith & Jonides, 1998). Recent findings support the hypothesis that working memory processes that involve higher task demand (e.g., manipulation of information as opposed to maintenance of information) are executed in the dorsolateral prefrontal region (e.g., digits backward; Conklin et al, 2007).

Multiple systems in addition to the dorsolateral prefrontal cortex are also activated during attention and set-shifting processes (Cohen, Malloy, Jenkins, & Paul, 2006; Hampshire & Owen, 2006). A recent study by Hampshire and Owen (2006) investigated the neuranatomical correlates of specific components of attentional control (e.g., set-shifting). They found that although the dorsolateral prefrontal cortex was active throughout a visual set-shifting task, additional neural correlates differed for other aspects of attentional control. For example, the ventrolateral prefrontal cortex was active when subjects divided their visual attention between tasks. In contrast, the orbitofrontal region was activated when subjects were given feedback based on their performance; specifically the lateral orbitofrontal region was activated during reversals resulting from negative feedback and the medial orbitofrontal region activated by positive feedback. Similarly, Chudasama and Robbins (2006) reported that reversals were affected by lesions in the orbitofrontal region. These findings indicate that multiple brain regions may be involved during complex tasks, with dorsal lateral prefrontal cortex corresponding to performing visual search, ventrolateral prefrontal cortex corresponding to shifts in attention, and lateral orbitofrontal regions corresponding to performing reversals (alternating response sets).

In further support of these findings on the fractioned anatomical correlates of attention, the ventrolateral prefrontal cortex and lateral orbitofrontal loop have also been implicated in tasks involving initiation and inhibition (Cohen et al, 2006; Lezak, Howieson, & Loring, 2004; Rubia, Smith, Woolley, Nosarti, Heyman, Taylor, & Brammer, 2006). Hodgson and colleagues (2007) found that the ventrolateral frontal cortex was involved in the inhibition of eye movements. Likewise, patients with right prefrontal lateral cortex (Vendrell, Junque, Pujol, Jurado, Molet, & Grafman, 1995) and orbitofrontal lesions have been shown to have impairment on go-no-go or Stroop tasks, which require patients to withhold or inhibit responses (Malloy et al, 2006).

There are multiple other regions associated with attentional networks in addition to the ones already mentioned. For example, subcortical structures are also implicated in attentional networks involving motor components. Motor planning involves connections between the basal ganglia and supplementary motor areas in the frontal cortex (Cohen et al, 2006) and engagement in motor control involves connections between the cerebellum and associated with frontal systems (Denckla, 1994). In addition, the anterior cingulate and its corresponding network (see Figure 1) have been implicated in vigilance and concentration (Jackson, Marrocco, & Posner, 1994; Lezak, Howieson, & Loring, 2004); however, these regions appear to be important for novel, rather than automatic tasks, and do not appear to be central to performance on executive functioning tasks (Baird, Dewar, Critchley, Gilbert, Dolan, & Cipolotti, 2006). While these additional networks are arguably involved in executive functioning, based on the literature to date, they appear to be secondary to prefrontal systems.

Gender Differences in Executive Functioning

There is some evidence to suggest that there may be gender differences in executive function abilities. Although some research indicates that there are no gender differences in the executive functioning domains of verbal fluency, planning, and organizing abilities (Welsh, Pennington, & Grossier), others have reported better female performance on verbal fluency and working memory tasks (Anderson et al, 2001) and set-shifting and problem solving tasks (Luboyeski, Han, Lansing, Holdnack, & Delis, 2009).

Gender differences that have been found in executive functions may be linked to differences in frontal-lobe development. Significant differences in brain volume have been reported for children between the ages of seven and 11 (Caviness, Kennedy, Richelme, Rademacher, & Filipek, 1996). Specifically, female children achieve adult-level brain volume between these ages they have less central white matter than same age males and adult age brains. In contrast, male children between age 7 and 11 have greater central white matter than same age females, but have not yet shown the reduction in brain volume found in adults. At full adult development, during the early twenties, males have approximately 10% greater overall brain volume than females. Although evidence suggests that grey matter decreases around puberty (i.e., brain volume decreases), females may undergo this synaptic pruning early, prior to age 7 to 11. Given these findings, it is possible that females may also show earlier development of executive functions development relative to males.

Even once adult-level brain size has been reached there may still be gender related differences in brain structure. These gender differences may the result of hormone levels (Bayer & Hausmann, 2009) as well as locations of androgen and estrogen receptors in the brain (Caviness, 1996; Durston et al., 2001). Hormones, such as estrogen, have been shown in some cases to affect both cerebral asymmetry and cognitive performance in women. There is also evidence suggesting that males have significant age-related increases in white matter volume in the left inferior frontal gyrus (Blakemore & Choudhury, 2006) and the amygdala (Durston et al, 2001) as a result of the onset of greater steroid levels in puberty, a pattern that is not evident with females. Thus, it is possible that hormones may modulate brain structure and function, resulting in notable differences in cognitive performance in men and women.

Neuropsychological Assessment of Executive Functioning

Initially, measurement of executive functioning was limited to assessments developed prior to the 1950's, before the evolution of contemporary neuropsychology and understanding of the individual components of executive functioning (Shunk, Davis, & Dean, 2006). Similar to the way in which the delineation of executive functioning arose gradually from clinical work with patients, measurement of executive functioning was compiled from assessments that were already in use. As psychologists were beginning to identify characteristics of their patients as "executive functioning" deficits, they were identifying aspects of the assessments they already had that tapped into these skill deficits. For example, while conducting an evaluation of a patient using an assessment of intellectual functioning, such as the Wechsler Adult Intelligence Scale

(WAIS), a psychologist might have noted that the patient also had difficulty in higher ordered cognitive abilities, such as planning. Although the WAIS was not developed to assess this latter skill per se, deficits that characterized executive dysfunction outside of the area of general cognitive ability were often noted.

Although many neuropsychological assessments currently used to measure executive functioning were not developed explicitly for this purpose, these assessments that were developed to assess intellectual functioning, memory, and attention have been adapted over the years to measure components of executive functioning. The lack of specific assessments of executive functioning is not surprising considering the lack of consensus and widely varying definitions of executive functioning (Denckla, 1994), as presented in previous sections. However, the attention that executive functioning has received recently in the literature is evidence of the movement towards agreement on what the executive functions consist of and how they can be operationalized.

Currently, there is substantial variability in the measurement of executive functioning by psychologists (Alvarez & Emory, 2006). One survey of members of the International Neuropsychological Society indicated that thirteen different assessments of executive functioning were currently in use by psychologists (Butler, Retzlaff, & Vanderploeg, 1991). This is problematic since little is known about the ability of these assessments to accurately measure aspects of executive functioning.

Furthermore, as previously discussed, there has been discussion as to whether the executive functions should be conceived of as a unitary measurement, or in terms of its separate components (Barkley, 1997; Denckla, 1994; Gioia, Isquith, Retzlaff, & Espy, 2002; Welsh, Pennington, & Grossier, 1991). If accepting the viewpoint of executive functions as a set of separate components, using a composite measure of executive functioning may fail to capture the multi-faceted nature of the domain. In contrast, examining only the individual components of executive functioning may fail to represent the inter-related processing of the components.

In addition, executive functioning often overlaps with other non-executive domains, such as language and memory (Denckla, 1994; Miyake et al, 2000). Since many traditional assessments were designed to assess processing within specific brain regions, the measurement of executive functioning has been adapted from tests of these domains (Alvarez & Emory, 2006). An example comes from memory tasks intended to tap into the learning of information concepts, such as the Rey Auditory Verbal Learning Test (RAVLT) or the California Verbal Learning Test (CVLT). Researchers have found that such tests, like these that intend to assess rote memory, also frequently assess the executive function of working memory. In addition, most assessments rarely produce a “clean” measure of executive functioning abilities. For example, as seen in the above example with the language based assessments RAVLT and CVLT, working memory can involve the processing of either verbal or non-verbal information, which are each processed in separate brain regions (Miyake et al, 2000).

Although historically assessments of executive functioning have been adapted from other neuropsychological assessments, researchers have conducted factor analyses on these assessments to investigate whether they measure an inclusive factor of executive functioning. For example, Miyake and colleagues (2000) examined performance on five commonly used tasks to measure executive functioning ability (Wisconsin Card Sorting Test, Tower of Hanoi, random number generation, operation span, and dual tasking) and found three separate factors: shifting, updating, and inhibition. Pineda and Merchan (2003) found five separate factors based on performance on different tasks: organization and flexibility from the Wisconsin Card Sorting Test, errors in Stroop reading and naming, time to execute Stroop, performance on Trail Making Test A and B, and verbal fluency. These findings were based on performance on multiple tasks of executive functioning, which is not surprising given that many tests used to measure executive functioning were not designed as such. Results pointing to multiple factors may be attributable to these executive functioning tasks differing widely in content (Denckla, 1994; Miyake et al, 2000).

As example, a factor analysis conducted by Boone and colleagues (1998) with four traditional assessments thought to measure executive functioning indicated that each of these tests measured distinct capabilities. A mixed sample of healthy individuals and patients presenting with various conditions in outpatient and inpatient clinics completed neuropsychological testing on the following executive functioning assessments: WCST, Stroop Test, Verbal Fluency Test (FAS), and Auditory Consonant Trigrams (ACT). Results indicated that the WCST loaded onto one factor, the Stroop and Verbal Fluency Tests loaded onto a second factor (along with the Digit Symbol subtest from the WAIS-R), and the ACT loaded onto a third factor (along with VIQ, PIQ, Digit Span, and Digit Symbol from the WAIS-R and the Rey-Osterrieth test). However, further analyses indicated that there was overlap between the three factors, which yielded an ultimate one-factor model that provided the best fit to the data. These results highlight that the measures of executive functioning represent distinct, but inter-related abilities. However, it is possible that these results reflect the overlap and distinction between *measurements* of executive functioning, rather than the actual qualities of the domain.

Although the number of factors comprising executive functioning is unclear, psychologists are converging on an accepted definition of executive functioning, which in turn will hopefully inform appropriate measurement of executive functioning. This process is driven forward by the emergence of comprehensive assessments of executive functioning. Two such assessments are the Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001) and the Behavior Rating Inventory of Executive Functioning (BRIEF; Roth, Isquith & Gioia, 2005). Both assessments intend to encompass much of the domain of executive functioning; however these two assessments appear strikingly different.

The D-KEFS was developed as a comprehensive measure of executive functioning to be administered by a trained professional. There are no composite scores to provide an index of overall executive functioning (Shunk, Davis, & Dean, 2006), rather, the D-KEFS considers executive functioning in terms of its individual components. The D-KEFS includes nine, individually administered tests that are modifications of pre-existing measures, as well as the inclusion of novel tests created by the authors and undeveloped tests from research studies (Shunk, Davis, & Dean, 2006). These nine tests include: Trail Making Test, Verbal Fluency Test, Design Fluency Test, Color-Word Interference Test, Card Sorting Test, Word Context Test, Twenty Questions

Test, Tower Test, and the Proverb Test. The D-KEFS measures planning, abstraction, verbal and visual fluency, inhibition, and set-shifting aspects of executive functioning. An advantage over previously used measures is that the D-KEFS allows for the measurement of both basic-level and higher-ordered abilities. Thus, in addition to performance scores, psychologists are also able to obtain process scores for their patients (Shunk, Davis, & Dean, 2006).

Whereas the D-KEFS is an administered assessment of individual tasks requiring executive functioning skills, the BRIEF is a questionnaire of executive functioning problem behavior, with self-report and informant report forms. The BRIEF was designed to assess the behavioral manifestations of executive functions (Gioia et al, 2002). As an "ecologically valid measure," the BRIEF assesses functioning in relation to the environment (Gioia & Isquith, 2004). It purports to capture not only difficulties in completing everyday executive tasks through the endorsement of problem behaviors, but also the ability to engage in everyday executive tasks through the absence of problem behaviors. The BRIEF-A, adult version, contains nine scales measuring the following executive functioning areas: inhibition, shifting, emotional control, monitoring, initiating, working memory, planning and organizing, organization of materials, and task monitoring (Roth, Isquith & Gioia, 2005).

In addition to the nine subscales, the BRIEF-A manual provides two-factor composite scales for behavioral regulation and metacognition, as well as a single-factor composite for general executive functioning ability (Roth, Isquith & Gioia, 2005). According to the BRIEF-A examiner's manual, factor analyses were conducted on the self-report form in both the normative sample (healthy 18-90 year olds) and a mixed clinical/healthy sample of adults. The two-factor model (behavioral regulation and metacognition) provided the best fit to the data in both samples, accounting for 73% and 76% of the variance, respectively. The two factors were reportedly highly correlated with each other (r = .783-.798).

Although there is no other research to date that has further investigated the factor structure of the BRIEF-A, several studies were found that conducted confirmatory factor analyses of the parent version of the child BRIEF. Using a mixed sample of 374 children (age 5-18), Gioia and colleagues (2002) tested four separate factor models using the 9 subscales of the parent BRIEF: a one factor model of a “Global Executive Composite,” a two-factor model of a “Behavioral Regulation” factor including the Inhibit, Shift, Emotional Control, and Self-Monitor subscales and a “Metacognition factor” including the Initiate, Working Memory, Plan/Organize, Organization of Materials, and Task Monitor subscales, a three factor model of a “Behavioral Regulation” factor including the Inhibit and Self-Monitor subscales, a “Emotional Regulation” factor including the Emotional Control and Shift subscales, and a “Metacognition” factor that included the same subscales as the two-factor model, and finally a four-factor model of the “Behavioral Regulation” and “Emotional Regulation” factors from the three-factor model, an “Internal Metacognition” factor including the Initiate, Working Memory, and Plan/Organize subscales, and a “External Metacognition” factor including the Organization of Materials, and Task Monitor subscales. They found that the three factor model provided the best fit to the data. However, in contrast, a second study with the parent BRIEF found that the two factor, Behavioral Regulation and Metacognition, model provided the best fit to a sample of 80 children with epilepsy (age 5-17; Slick, Lautzenhiser, Sherman, & Eyrl, 2006).

Research was conducted between the BRIEF-A and other neuropsychological assessments of executive functioning, as part of the standardization of the BRIEF-A and as presented in the examiner’s manual (Roth, Isquith & Gioia, 2005). It was reported that strong correlations (r = .50-.74) were found between most of the BRIEF-A subscales and the Executive Dysfunction and Apathy subscales of the Frontal Systems Behavior Rating Scale (FrSBe) and modest correlations (r = .47-56) were found between most of the BRIEF-A subscales and the Disinhibition subscale of the FrSBe. However, the Shift and Emotional Control subscales of the BRIEF-A were not significantly related to any of the FrSBe subscales. Similar findings were reported between the BRIEF-A and the Dysexecutive Questionnaire (DEX) (a subscale of the Behavioral Assessment of the Dysexecutive Syndrome battery). Specifically, modest to strong correlations (r = .38-.84) were found between all subscales of the BRIEF-A and the composite score of the DEX. The convergent findings between the BRIEF-A and two other proposed measures of executive functioning (i.e., FrSBe and DEX) indicate that similar constructs are measured in all three assessments. However, these results are limited in that all assessments are self-report measures and not objective assessments.

Though rating scales are often used clinically in conjunction with objective measures to provide an ecological perspective, few studies have investigated the relationship between these two types of assessments. A recent study conducted by Rabin et al (2006) compared the performance of older, cognitively impaired adults on the BRIEF-A and other objective neuropsychological assessments. In addition to the BRIEF-A, participants were administered the CVLT-II, the Dementia Rating Scale-2 (DRS-2), the WCST, D-KEFS Trail Making Test, D-KEFS Letter Fluency, and the Wechsler Memory Scale-3 (WMS-III) Digit Span and Visual Reproduction subtests. A moderate correlation (r = -.37) was found between the WMS-III Visual Reproduction subtest and the Behavioral Regulation Index of the BRIEF-A self-report; however there were no significant correlations between the BRIEF-A and any of the objective executive functioning assessments mentioned above.

Similarly, Vriezen et al (2002) found that the parent report version of the child BRIEF did not correlate with any objective executive functioning neuropsychological assessments. Specifically, these researchers compared parent reported executive functioning behaviors on the BRIEF with children's performance on the Wechsler Intelligence Scale for Children-III (WISC-III), the WCST, the Trail Making test part B, and the Verbal Fluency test. Although the Metacognition Index of the BRIEF was moderately correlated (r = -.30) with Verbal IQ on the WISC-III, there were no significant relationships found between the BRIEF and the measures of executive functioning.

Another study was found that investigated the relationship specifically between the D-KEFS and the parent version of the child BRIEF. Parrish and colleagues (2007) looked at the performance of epileptic and non-epileptic children (age 8-18) on executive functioning measures. Children were assessed using the free sort description score of the

Card Sorting Test, the category switching accuracy score of the Verbal Fluency Test, and the Inhibition Task timing score of the Color-Word Interference Test from the D-KEFS. Parents of the children completed the parent version of the BRIEF and scores for the Behavioral Regulation Index and Metacognition Index were computed. In this study significant correlations were found between all three D-KEFS measures and the Metacognition Index of the BRIEF.

Depressive Symptomology and Assessment

Depression is a common psychiatric mood disorder, marked by apathy, loss of interest in pleasurable activities, and change in sleep and/or appetite (APA, 2000). Clinical depression affects about 10% of the normal population; however it may be more debilitating in people who also have another physical or psychological illness (Schmitz, Wang, Malla, & Lesage, 2007). In particular, depression is often prominent in individuals with neurological disorders, such as Parkinson's disease, Huntington's disease, AIDS dementia, and stroke (Howieson, Loring, & Hannay, 2004). Given the incidence of comorbidity in patients seeking neuropsychological evaluation, a thorough understanding of the association of depression and assessment is warranted.

Previous research indicates that depression affects performance on standardized assessments of executive functioning (Elliot, 1998; Goodwin, 1997; Hartlage, Alloy, Vazquez, & Dykman, 1993; Walter, Wolf, Spitzer, & Vasic, 2007), but not consistently on tests of general cognitive ability (Channon, 1996; Landro, Stiles, & Sletvold, 2001). For example, depression in young, non-brain injured patients can interfere with performance on tasks of mental processing and attention (Hartlage, Alloy, Vazquez, &

Dykman, 1993; Howieson, Loring, & Hannay, 2004). Furthermore, Channon (1996) found significant differences between depressed and non-depressed individuals on the Wisconsin Card Sorting Test, specifically in set-shifting and descriptions of sorting categories; however differences were not found within the domain of verbal intellectual ability.

Patients with depression are often reported to have structural brain abnormalities. There is some evidence to suggest that depressed patients have a reduction in total frontal lobe brain volume; however, functional abnormalities appear to be more distinct (Goodwin, 1997). A meta-analysis of research on the cognitive performance of depressed patients revealed that neuropsychological impairment in patients with depression typically tends to be global and diffuse (Veiel, 1997). Similarly, Pardo and colleagues (1996) found that depressed patients' showed global slowing on visual scanning tasks regardless of task difficulty. Walter, Wolf, Spitzer, & Vasic (2007) demonstrated that depressed patients were significantly slower independent of task load. However, in addition, these researchers found that depressed patients showed greater activation in the left dorsolateral prefrontal cortex with highest cognitive load and greater activation in the ventromedial prefrontal cortex during the control condition, indicating that depressed patients may show a frontal compensatory mechanism.

This finding was congruent with other researchers who have found that although depressed patients may show global impairment, greater deficits are often found on tasks involving the frontal lobes (Veiel, 1997). Thus although depressed patients may show a generally suppressed neuropsychological profile, including a slower processing speed, performance on tasks involving frontal regions tend to be most affected. For example, Veiel (1997) found in his meta-analysis that depressed patients had greater deficits on tasks of mental flexibility and control, scanning and visuomotor tracking, visuospatial functions, and verbal fluency than non-depressed patients.

Neuroimaging studies provide further information on the neurobiological aspects of depression and the involvement of the frontal lobes. Mood disorders, like depression, typically involve changes in affect, reward, motor activity, sleep, appetite, sexual interest, concentration, and memory (Goodwin, 1997). Neuroimaging studies indicate that the anterior structures and basal ganglia-thalamocortical pathways are often affected in depressed patients (Goodwin, 1997). Since the basal ganglia-thalamocortical pathways involve motor, oculomotor, dorsolateral prefrontal, lateral orbitofrontal, and anterior cingulate circuits (Goodwin, 1997; Levin, Heller, Mohanty, Herrington, & Miller, 2007), it is not surprising that depressed patients also show reduced metabolic activity in the left dorsolateral prefrontal cortex, anterior-medial prefrontal cortex, the caudate nucleus, and the paralimbic cortex, including the inferior-posterior frontal cortex, anterior temporal cortex, and cingulated gyrus (Veiel, 1997). The dorsolateral prefrontal cortex typically is thought to regulate executive functions in general (Veiel, 1997) and is thought to be involved in verbal fluency tasks (Goodwin, 1997). The anterior-medial prefrontal cortex is thought to subserve effortful processing (Veiel, 1997). The ventral frontal lobe, including the paralimbic cortex, appears to be involved in the expression of affect; lesions in this area also can result in disinhibition and deficits in visual discrimination (Goodwin, 1997) as well as memory functions (Veiel, 1997).

Landro, Stiles, and Sletvold (2001) found that depressed individuals had suppressed performance on tasks involving selective attention as measured on the Automated Psychological Test, working memory as measured on the Paced Auditory Serial Addition Test, and verbal fluency as measured by the Controlled Oral Word Association test (FAS). Differences were not found on measures of flexibility as measured by the trail making test (TMT) A and B, short term memory as measured by digits forward, verbal long term memory as measured by the Randt Memory Test, visuomotor tracking as measured by the digit symbol task, motor function as measured by the Automated Psychological Test, nonverbal long term memory as measured by the Kimura Recurring Recognition Figure Test, and visuospatial function as measured by the Block Design subtest of the WAIS. This study also compared intellectual functioning between depressed and non-depressed groups using the Similarities subtest from the WAIS found no significant differences between groups.

Similarly, Austin and colleagues (1999) found that depression affected performance on sustained attention and set-shifting tasks. However, Pardo and colleagues (1996) found that depressed patients showed no differences in sustained attention as measured by reaction time on a visuospatial task. Mixed results may be the result of construct differences between neuropsychological tasks. For example, there is evidence that depression interferes with effortful attention as opposed to automatic attention (Hartlage, 1993). Effortful attention is defined as engaging in thoughts involving conscious awareness and inhibition of other pathways (Hartlage, 1993), characteristics of executive functioning processes.

Some evidence suggests that selective impairments exist in depressed patients, specifically for patients suffering from frontal lobe deficits. For example, patients with Alzheimer's disease and posterior cortical dementia have relative sparing of executive functions, whereas frontal-subcortical dementia and Parkinson's patients show greater deficits in executive functioning (Elliot, 1998). In particular, depressed patients tend to demonstrate a range of cognitive deficits; however the greatest impairment appears to be on effortful, executive functioning tasks (Elliot, 1998; Levin et al, 2007).

Although the majority of research underscores the impact of depression on executive functioning using objective assessments, there has been some literature highlighting the relationship between depressive symptoms and self-report questionnaires that intend to capture executive functioning. Rabin et al (2006) found significant correlations between the Geriatric Depression Scale (GDS) and the Metacognition Index and Behavioral Regulation Index of the BRIEF-A ($r = .37$ and $.36$, respectively) in older adults. Similarly, the BRIEF-A examiner's manual reported modest to moderate correlations ($r = .31$-$.54$) between the GDS and BRIEF-A subscales in a sample of elderly adults (Roth, Isquith, & Gioia, 2005).

The BRIEF-A examiner's manual also reported significant correlations between the BRIEF-A and the Clinical Assessment of Depression (CAD) and the Beck Depression Inventory-II (BDI-II; Roth, Isquith, & Gioia, 2005). In the former analysis, the strongest correlations ($r = .37$-$.65$) were found between the BRIEF-A and the Cognitive and Physical Fatigue subscale of the CAD, with the Depressed Mood, Anxiety/Worry, and Diminished Interest subscales of the CAD modestly to moderately correlated with the

BRIEF-A (r = .37-.62). Interestingly, however, the Task Monitor and Organization of Materials subscales of the BRIEF-A were not significantly correlated with any of the CAD subscales. With respect to the BDI-II, the BRIEF-A subscales were moderately correlated with the BDI-II composite score (r = .45-.59), with the exception of the Organization of Materials subscale, which was modestly correlated (r = .29). Overall, these results indicate that the BRIEF-A is sensitive to depressive symptomology, as reported on rating scales of depression.

Summary and Current Study

The findings presented above underscore the importance of studying the domain of executive functioning and neuropsychological assessments which intend to measure executive functions. While the literature has made significant strides in defining executive functioning and describing specific areas comprising these higher-ordered cognitive functions, additional research integrating neuroanatomical and psychodevelopmental aspects of executive functioning is warranted. Discrepancies were found in the neuropsychological assessment of executive functioning, with wide variability in the components of executive functioning assessed and in the assessments that are used. Further examination of assessments of executive functioning was necessary to determine their ability to measure this cognitive domain as well as their usefulness in clinical practice.

The recent emergence of two comprehensive assessments of executive functioning has contributed to the demands of this field of study. However, these assessments differ in terms of proposed constructs and measurement (objective versus subjective or third-person versus first-person). It was unclear if these assessments also measure divergent constructs. Previous research has investigated executive functioning with patients suffering from neurological disorders involving impairment within this domain. However, few studies have investigated the relationship between depressive symptomology and executive functioning assessment, despite the shared neurobiological substrates implicated in both. Research that has examined the relationship between depression and executive functioning has often used clinical populations (e.g., inpatient or outpatient samples). Though study of these clinical populations has provided invaluable information for understanding executive functioning, further study was needed within non-clinical populations.

In light of the limitations in the literature to date highlighted above, the current study sought to extend the literature in several respects. The current study investigated the construct of executive functioning in a healthy, mixed-gender young adult population, during a period of time when executive functioning abilities have been proposed to be at their peak (Welsh, Pennington & Grossier, 1991; Barkley, 2001; Ylvisaker & Feeney, 2002). This study compared the construct of executive functioning through the use of two comprehensive assessments of executive functioning: the D-KEFS and the BRIEF-A. Given the association in the literature between depression and the frontal lobes and the influence of depressive symptomology on performance on neuropsychological tasks, the current study also compared the relationship of depressive symptomology to performance on each of these assessments. Possible gender differences in executive functioning were also explored.

Hypotheses

Relationship of EF to gender and depressive symptomology

It was predicted that scores on both the BRIEF-A and D-KEFS were affected by depressive symptomology, based on previous literature. However, it was predicted that the subjective executive functioning measure (i.e., the BRIEF-A) was more strongly correlated with the self-report depressive symptom rating scale (i.e., the BDI-II) than the objective executive functioning measure (i.e., the D-KEFS). It was also predicted that there would be gender differences in performance on both executive function measures, with females showing greater executive functioning ability. Given the higher incidence of depressive symptomology in females, analyses explored whether there were significant gender by depressive symptom interactions associated with executive functioning scores.

Relation between D-KEFS and BRIEF-A

It was predicted that subscales of the Metacognition Index of the BRIEF-A would be related to the Card-Sorting, Verbal Fluency, and Color-Word Interference tests of the D-KEFS, based on previous work from Parrish and colleagues (2007).

In exploratory analyses, it was predicted that the subscale Shift of the BRIEF-A would be significantly related to each of the D-KEFS switching tasks, the Inhibit subscale of the BRIEF-A would be related to the Inhibit task of the Color-Word Interference test of the D-KEFS, and the Initiate subscale of the BRIEF-A would be related to the Letter and Category subtests of the D-KEFS.

Factor Structure of EF

BRIEF-A

Three factor models, based on previous literature, were examined using the nine BRIEF-A subscales (Inhibit, Shift, Emotional Control, Self-Monitor, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Task Monitor). Model 1 consisted of a one-factor model (global executive functioning factor; see Figure 2). BRIEF-A Model 1 was based on the theoretical assumption that there is significant overlap between executive functioning abilities. The following BRIEF-A theoretical models were based on the assumption that executive functioning abilities are distinct. Model 2 consisted of a two-factor model, as provided in the BRIEF-A manual (behavioral regulation and metacognition factors; see Figure 3). Model 3 was a three-factor model of a behavioral regulation factor, an emotional regulation factor, and a metacognition factor (see Figure 4). Model 4 was a four-factor model of an internal metacognition factor, an external metacognition factor, an emotional regulation factor, and a behavioral regulation factor (see Figure 5).

D-KEFS

Based on previous research three factor models were examined using seven tasks from five D-KEFS subtests (Trail Making Test, Verbal Fluency, Design Fluency, Color-Word Interference, and Card Sorting). Model 1 consisted of a one-factor model (unitary construct model of executive functioning; see Figure 6). D-KEFS Model 1 was based on the theoretical assumption that executive functioning abilities and neuropsychological tasks overlap. Model 2 consisted of a three-factor model, based on the work of Miyake

Figure 2. BRIEF-A model 1.

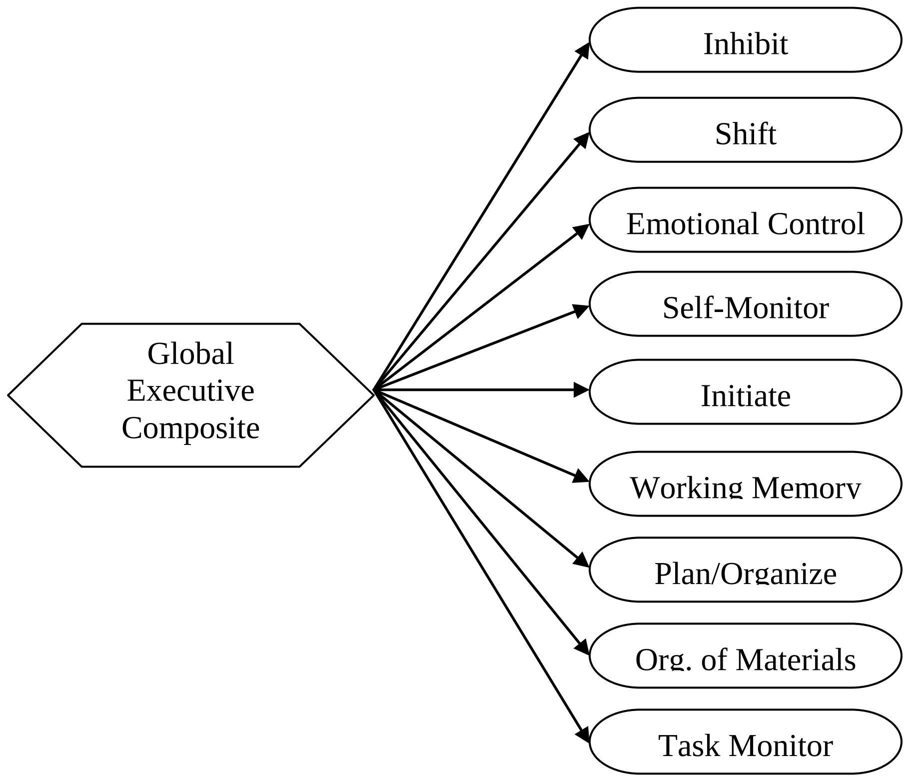


Figure 3. BRIEF-A model 2.

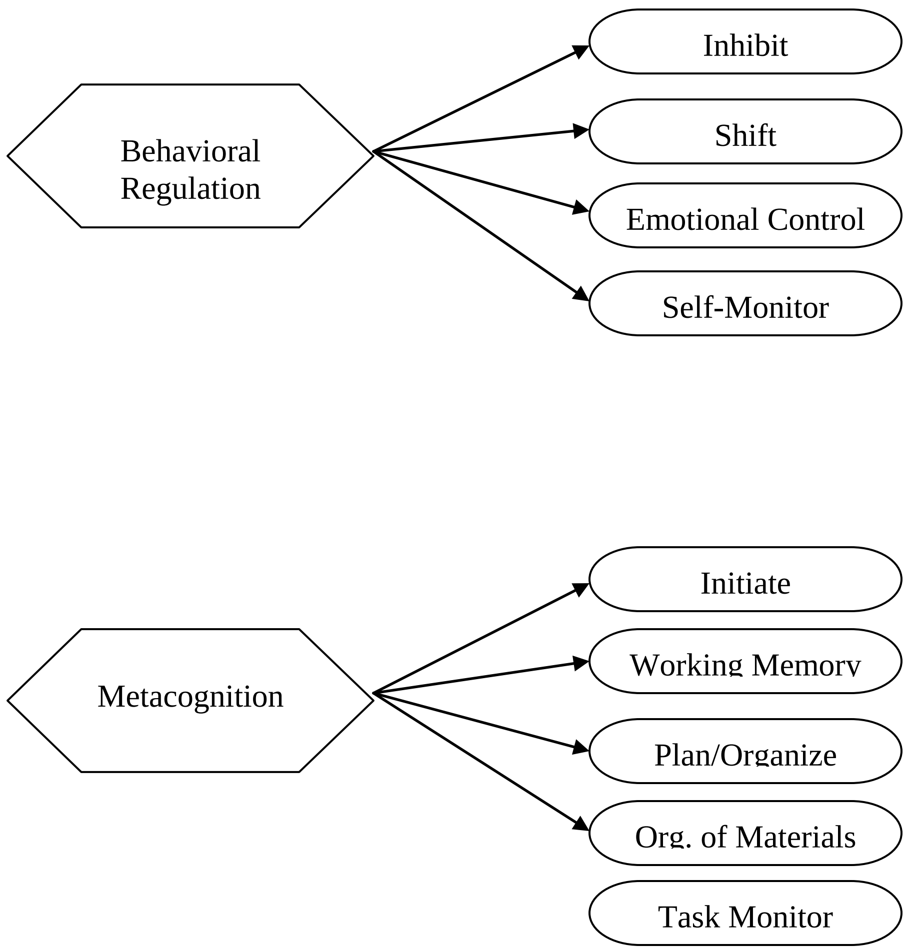


Figure 4. BRIEF-A model 3.

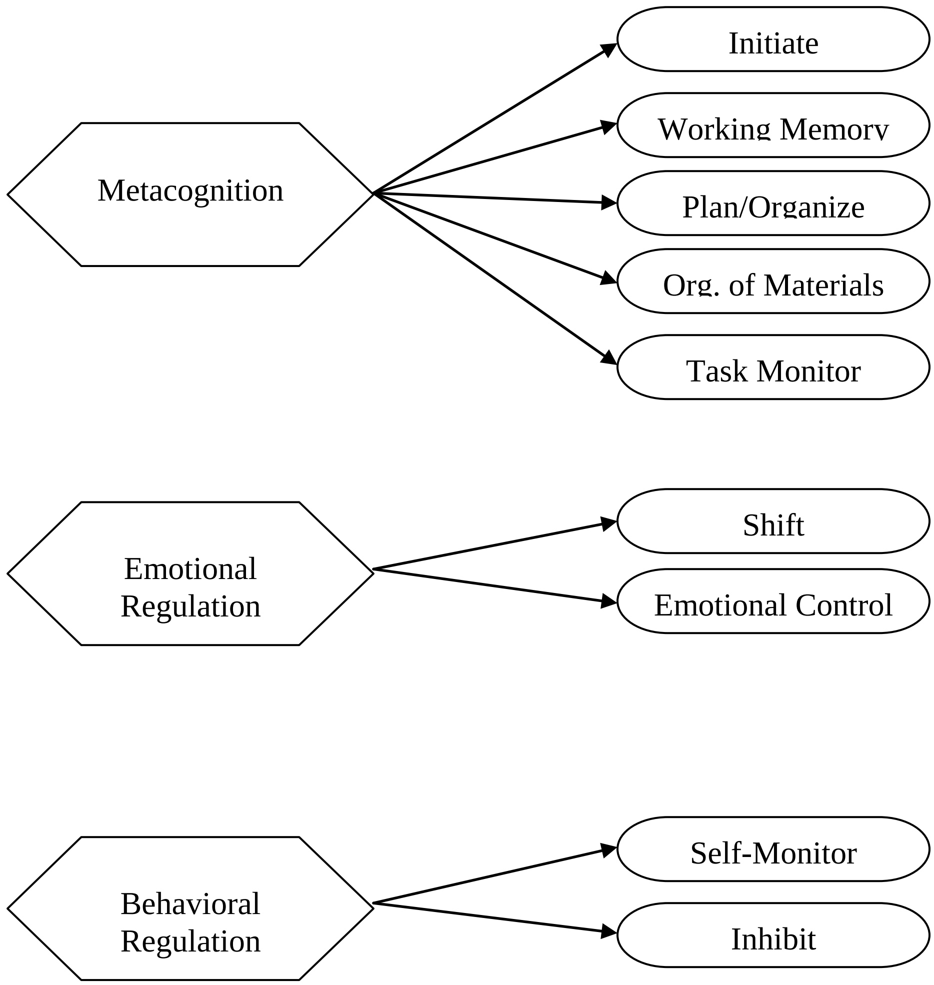


Figure 5. BRIEF-A model 4.

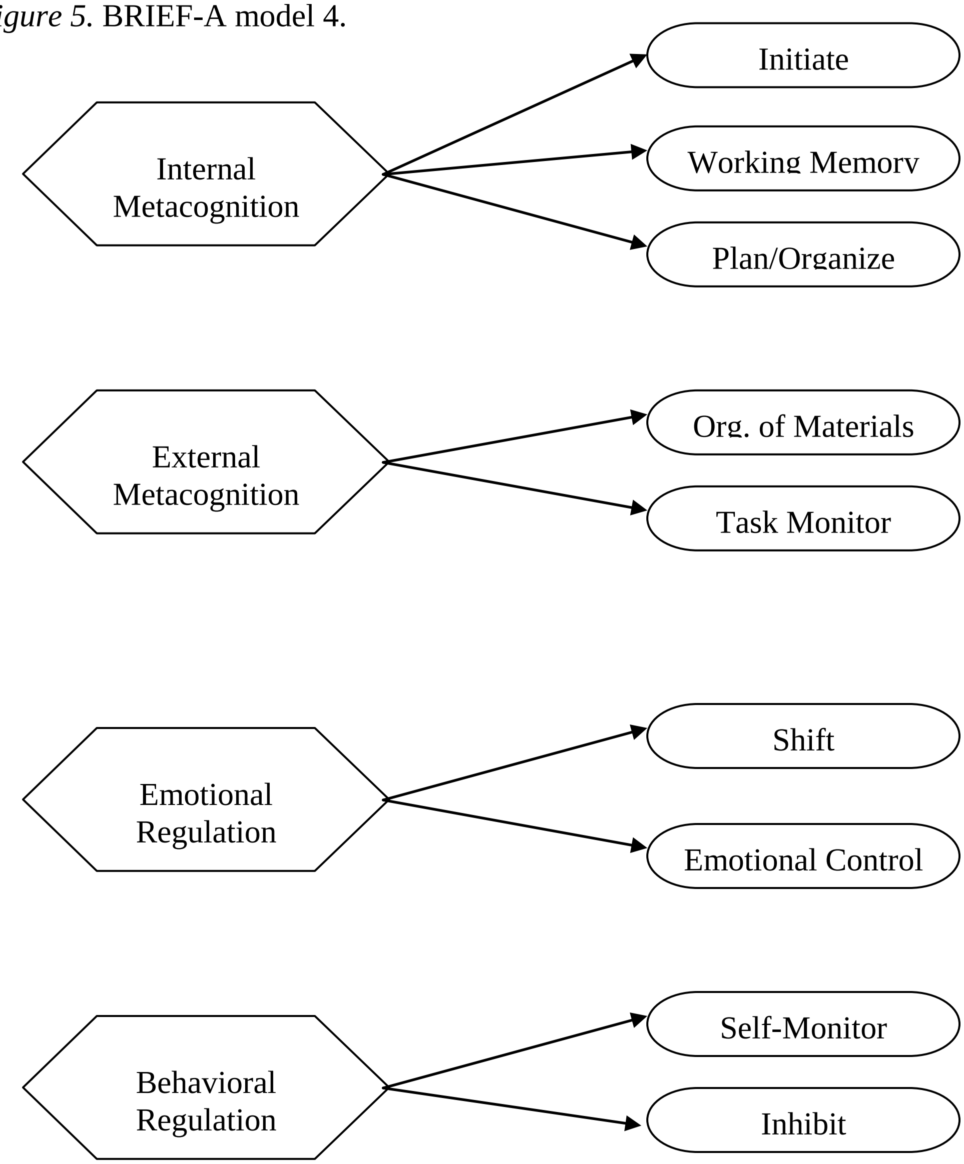
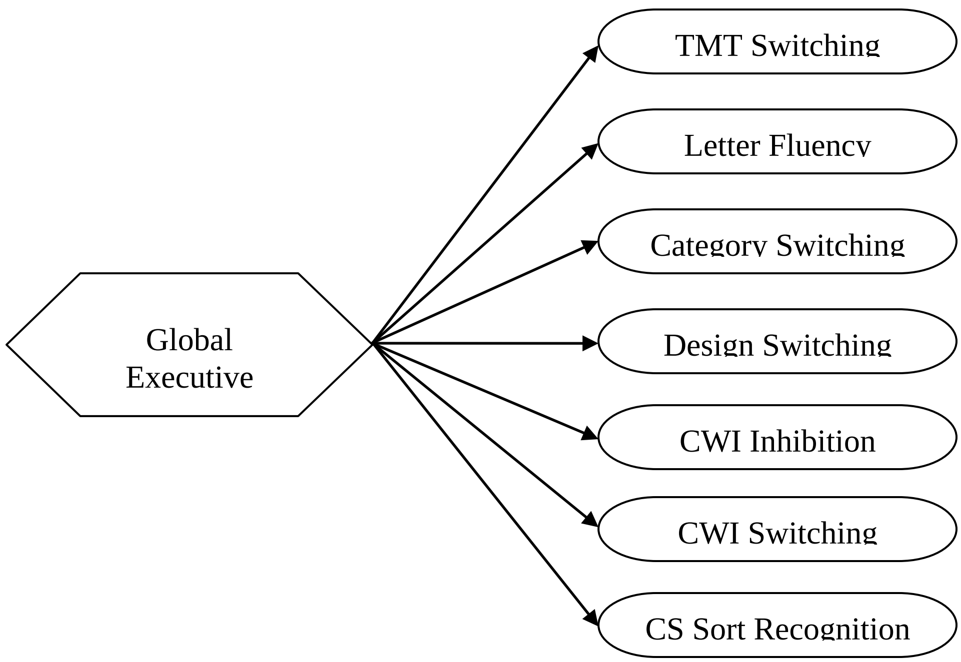


Figure 6. D-KEFS model 1.



et al (2000), including a set-shifting factor, an inhibition factor, and a fluency factor (see Figure 7). The factor analysis performed by Miyake et al (2000) found that performance on five neuropsychological assessments tapped into three factors of executive functioning skills, rather than a separate factor for each assessment. Thus, D-KEFS Model 2 was based on the theoretical assumption that neuropsychological tasks overlap in their measurement of executive functioning skills. Model 3 consisted of a five-factor model, based on the primary measures of each subtests of the D-FEFS (see Figure 8). D-KEFS Model 3 was based on the theoretical assumption that each neuropsychological task measures a separate executive functioning ability.

Figure 7. D-KEFS model 2.

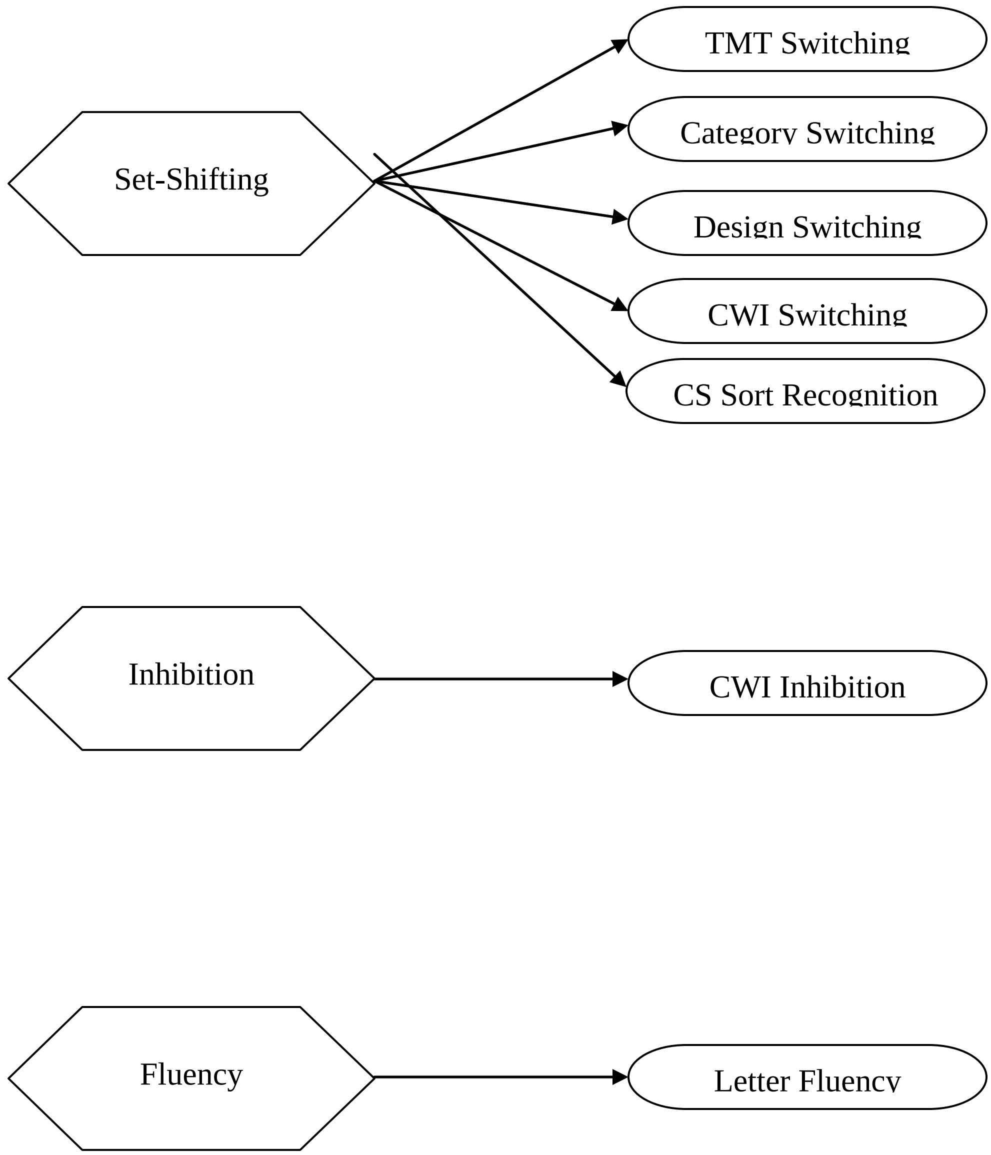
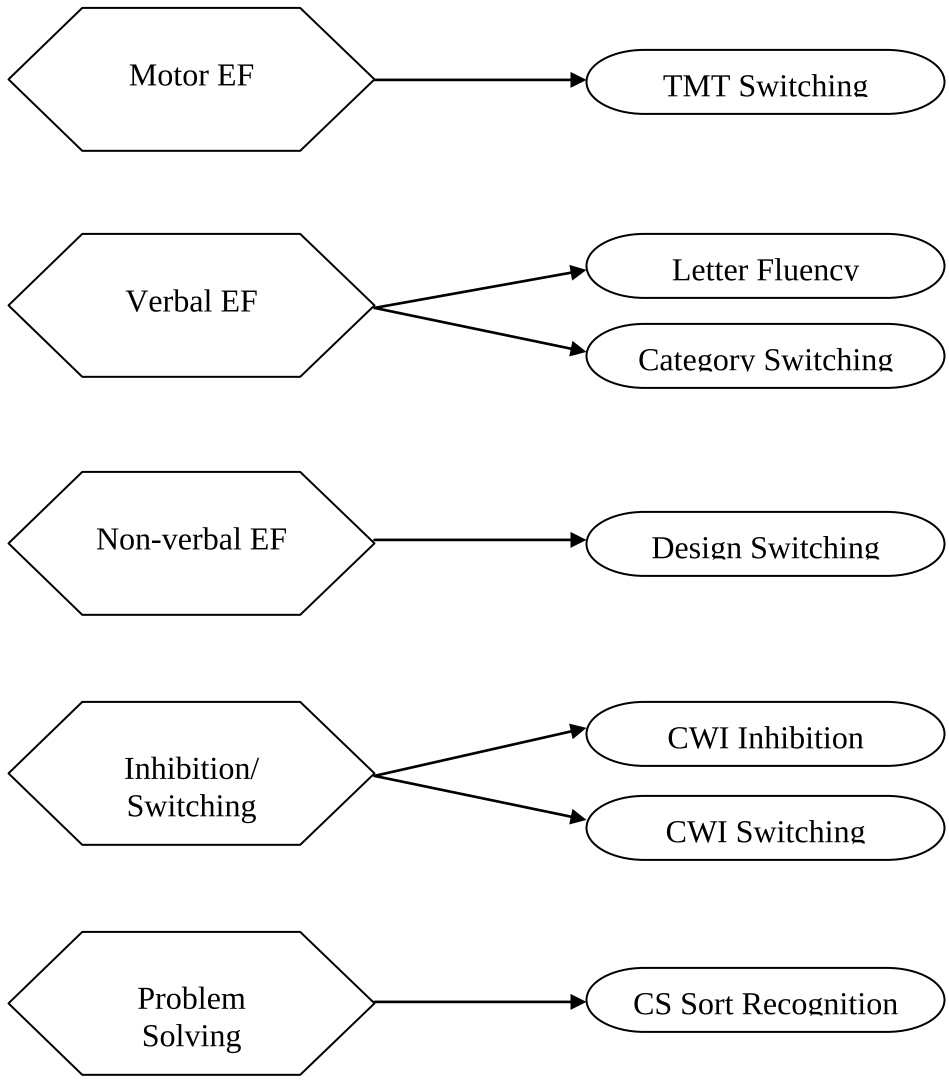


Figure 8. D-KEFS model 3.



CHAPTER THREE

METHODS

Participants

One hundred college students were recruited from an introductory psychology class from a midsized university in the Midwest. Prior to study participation, students were provided with a brief description of the study as well as the nature of the research. Students were invited to participate if they had not yet participated in the study, met age criteria (over age 18) and spoke fluent English. Exclusion criteria included the following, as they could affect performance on neuropsychological assessments: a previous history of electroconvulsive therapy (ECT), a previous history of neurological illness, a previous history of treatment for alcohol or drug dependence or abuse, and currently taking medication that affects the ability to think clearly or any kind of neurological medication. Students provided informed consent and were administered a battery of cognitive, neuropsychological, and behavioral assessments by trained graduate or advanced undergraduate psychology research assistants. Assessments took up to four hours to complete, and students received course credit for their participation. All procedures were supervised by a licensed clinical neuropsychologist and approved by the university's institutional review board.

Data collection took place over a period of two years during both fall and spring semesters. Five students out of the 100 students recruited had incomplete data due to administrator errors, thus a total of 95 students were included in the current study (82% female). Demographic data for the sample are presented in Table 1. The majority of the sample was 19 years of age, female, in their first year of college (12 years of education), and Caucasian.

Measures

WASI

The Wechsler Abbreviated Intelligence Scale (WASI; Wechsler, 1999) was designed to provide an abbreviated measure of intellectual functioning (Full Scale IQ) and consists of four subtests (Block Design, Vocabulary, Similarities, and Matrix Reasoning). The WASI was nationally standardized with a representative sample of 2, 245 individuals aged 6-89 years. The WASI has been demonstrated to have good reliability and validity. According to the WASI manual, the WASI four-subtest FSIQ score has a reliability coefficient of .96 for ages 17-19 and 20-24, which is consistent with reliability coefficients for a FSIQ obtained from the full Wechsler Adult Intelligence Scale-Third Edition (WAIS-III). The WASI manual reports that the WASI FSIQ and the WAIS-III FSIQ are highly correlated ($r = .92$). Administration of the WASI takes approximately 30 minutes.

D-KEFS

The Delis-Kaplan Executive Functioning System (D-KEFS; Delis, Kaplan, & Kramer, 2001) was developed to be a comprehensive measurement of executive functioning abilities. The D-KEFS contains normative data for age 8-89, representative of the U.S. population according to the 2000 United States Census, with gender,

Table 1

Sample Characteristics

(N= 95)

	Mean	Standard Deviation
Age	19.09	2.21
Education	12.54	0.95
	Number	Percent of Sample
Gender		
Male	17	17.9
Female	78	82.1
Race/Ethnicity		
Caucasian	72	75.8
African American	4	4.2
Latino	8	8.4
Asian	8	8.4
Middle Eastern	1	1.1
Biracial/Other	2	2.1

race/ethnicity, years of education, and geographic region stratified by age group. Five D-KEFS tests were selected for use in this study: Trail Making, Design Fluency, Verbal Fluency, Color-Word Interference and Card Sorting Tests. Administration of these five subtests of the D-KEFS takes approximately 45 minutes.

The Trail Making test is a motor task consisting of a visual cancellation task, and a series of connect-the-circle tasks (Delis, Kaplan, & Kramer, 2001). The latter tasks require the participant to make serial connections between only numbers (e.g., 1, 2, 3), only letters (e.g., A, B, C), alternating connections between numbers and letters (e.g., A, 1, B, 2, etc.). There is also a motor speed task which requires the participant to connect circles following a dotted line, which, together with the number sequencing and letter sequencing tasks, are intended to serve as component tasks for the letter-number switching task. This switching task is intended to serve as the primary executive functioning task for Trail Making. The D-KEFS Trail Making Switching Task uses a similar format to the Trails B test, a commonly used neuropsychological assessment considered to measure abstraction, set maintenance, and flexibility (Malloy et al, 2006). The D-KEFS Trail Making Test utilizes completion time as the primary performance measure. Internal consistency for the D-KEFS Trail Making Test was reported to be in the moderate to high range (Delis, Kaplan, & Kramer).

The Verbal Fluency Test is a verbal task consisting of three conditions: Letter Fluency, Category Fluency, and Category Switching (Delis, Kaplan, & Kramer, 2001). The Letter Fluency condition, similar to the Controlled Oral Word Association Test, requires the participant to generate words that begin with a certain letter (e.g., F, A, or S).

The Category Fluency condition, which is intended to serve as a component task for the switching condition, requires participants to generate words that belong within a semantic category (e.g., animals and boy’s names). The Category Switching condition requires participants to alternate between naming words within two semantic categories (e.g., name a fruit, then a piece of furniture, then a fruit, etc.). The Letter Fluency and Category Switching conditions were intended to measure aspects of executive functioning, and typically are more sensitive to frontal lobe lesions than Category Fluency (Delis, Kaplan, & Kramer, 2001). The Letter Fluency task is thought to measure initiation and dual processing attention (e.g., observing multiple rules of the task). The Category Switching condition is intended to measure fluency, flexibility, and set-shifting. The primary performance measure for Verbal Fluency tasks is the total number of correct responses in 60 seconds; however the Category Switching condition also includes a primary measure of switching accuracy, which measures the correct number of switches between categories. Internal consistency for the Verbal Fluency Test was reported to be $\alpha = .80$ and .85 for Letter Fluency and $\alpha = .53$ and .59 for Category Switching (for ages 16-19 and 20-29, respectively; Delis, Kaplan, & Kramer, 2001).

The Design Fluency Test was designed as a nonverbal analogue to the Verbal Fluency Test and consists of three conditions: Filled Dots, Empty Dots, and Switching. In each condition, the participant is required to draw as many designs as possible in 60 seconds. The Filled Dot condition presents the participant with boxes containing filled dots. The participant is required to draw different designs in each box using filled dots. In the Empty Dot condition, the participant is presented with boxes containing an equal number of filled and empty dots. The participant is asked to draw different designs using only the empty dots and inhibit from using the filled dots. In the Switching condition, the participant is again presented with boxes containing both filled and empty dots and asked to draw designs by alternating connections between filled and empty dots. The Filled and Empty Dot conditions were intended to serve as component tasks for the Switching condition. The primary performance measure for the Design Fluency Test is number of correct designs drawn in each condition. Although the Empty Dot condition requires the participant to inhibit from using the filled dots, significant differences were not found between this condition and the Filled dot condition in the standardization sample of the D-KEFS, indicating that the Empty Dot condition did not require additional burden, or higher level ability in healthy individuals. The Switching condition, however, was intended as a measure of set-shifting. Internal reliability was not reported for Design Fluency due to item interdependence (Delis, Kaplan, & Kramer, 2001).

The Color-Word Interference Test was designed to be similar in structure to the Stroop Test and consists of four conditions: Color Naming, Word Reading, Inhibition, and Inhibition/Switching. The Color Naming and Word Reading conditions were designed as component measures for the Inhibition and Inhibition Switching conditions. The Color Naming condition requires participants to name the color of ink patches. The Word Reading condition requires participants to read color words printed in black ink. The Inhibition condition requires participants to read the color of ink that words are printed in. Like the traditional Stroop Test, the Inhibition condition of the D-KEFS intends to measure the executive function of inhibition since the participant must inhibit reading the words in order to name the dissonant ink colors that the words are printed in. The Inhibition/Switching condition requires the participant to alternate between reading the printed color words and naming the dissonant ink colors. This condition is intended to measure both verbal inhibition and flexibility or set-shifting. The primary performance measure for the Color-Word Interference Test is time taken to complete each condition. Internal consistency for the Color Naming and Word Reading Tests was reported to be high (α = .75-82 for ages 16-29; Delis, Kaplan, & Kramer, 2001).

The Card Sorting Test was designed to measure concept-formation and problem solving (Delis, Kaplan, & Kramer, 2001). It consists of two conditions: Free Sorting and Sort Recognition. In the Free Sorting condition, the participant is required to sort and describe the sorting rules of two sets of six cards that can be sorted into two groups, with three cards in each group. In the Sort Recognition condition the examiner sorts the two sets of cards into two groups, with three cards in each group, and the participant is required to describe how the cards have been sorted in both groups. The cards can be categorized into a maximum of eight target sorts: three based on verbal-semantic information (e.g., clothing and parts of the body) and five based on visual-spatial features (e.g., filled triangles and unfilled triangles). Thus, the Card Sorting Test intends to provide measures of verbal and non-verbal problem solving. The Free Sorting condition is also intended to measure the executive function of initiation, as the participant must spontaneous sort the sets. The primary performance measures for both conditions of the Card Sorting test is the description score (the participant’s ability to describe the sorting rules), which intends to measure concept formation. The Free Sorting condition also provides a primary performance measure of number of correct sorts. This measure is indicated for assessing individuals with impairments in expressive language and is thought to be less informative about higher level functioning. In contrast, the description score measure is thought to provide information about the ability to transfer knowledge into behavior and flexibility in thinking. Internal consistency for the Free Sorting Condition was reported to be moderate to high (α = .73-.77 for ages 16-29; Delis, Kaplan, & Kramer, 2001).

BRIEF-A

The Behavior Rating Inventory of Executive Function, Adult Version (BRIEF-A; Roth, Isquith & Gioia, 2005) is a 75 item self-report that intends to capture executive functioning across a range of situations and takes about 10-15 minutes to complete. Participants report if a behavior is “never,” “sometimes,” or “often” a problem. The BRIEF-A includes scales which provide information on clinical range deficiencies within a Global Executive Composite (GEC), two indices: the Behavioral Regulation Index (BRI) and the Metacognition Index (MI), and nine subscales. The BRI includes the Inhibit, Shift, Emotional Control, and Self-Monitor scales. The MI includes Initiate, Working Memory, Plan/Organize, Organization of Materials, and Task Monitor scales. Higher scores on BRIEF-A scales indicate more problem behaviors within the particular executive skill component. The BRIEF-A also includes three validity scales: Negativity, Infrequency, and Inconsistency. The BRIEF-A has been standardized and validated for ages 18-90. Internal consistency was reported at α = .93-.96 for the indexes (MI and BRI) and α = .73-.90 for the clinical subscales (Roth, Isquith, & Gioia, 2005).

The Behavioral Regulation Index (BRI) is composed of Inhibit, Shift, Emotional Control, and Self-Monitor subscales (Roth, Isquith, & Gioia, 2005). The BRI contains items that intend to assess the ability to exhibit appropriate regulatory functions. The Inhibit subscale contains eight items and intends to measure the behavioral inhibition component of executive functioning, which includes impulse control. Individuals who are within the clinical range on this subscale may display higher levels of physical activity, have tendencies to interrupt others or engage in disruptive behavior. The Shift subscale contains six items that intend to assess flexibility and the ability to attend to various tasks as needed. Participants in the clinical range on this subscale may show greater difficulty shifting their attention from one task to another, may be inflexible in their responses and have an inability to transition between subject matters. The Emotional Control subscale contains 10 items. This subscale intends to assess the executive function of self regulation of affect, motivation and arousal. Adults with deficiencies in this component of executive functioning may have a difficult time regulating their emotions and may display inappropriate or overly exaggerated emotional responses. The Monitor subscale contains five items and intends to assess the ability to monitor behavior. The items represent the adult's awareness of how his/her behaviors influence others. The adult who shows deficit in this ability may have difficulty monitoring his/her work on given tasks and displays an inability to understand one's effects on others.

The Metacognition Index (MI) is composed of the Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials subscales (Roth, Isquith, &

Gioia, 2005). The MI is supposed to assess the adult's ability to initiate and work through cognitive tasks. An important component of the MI is intended to be working memory, which is an executive function that aids the adult in engaging in problem solving behavior. The MI is also supposed to measure the ability to plan, organize, and engage in problem solving. The Initiate subscale contains eight items which intend to assess the ability to get started on a task. It asks questions about an individual's ability to generate ideas and/or problem solving strategies. Participants with difficulties in this area may have trouble beginning a task. The Working Memory subscale contains 12 items. This subscale is supposed to assess an individual's ability to hold and manipulate information. The Working Memory subscale includes items asking about the ability to complete tasks once started and being able to remember the steps have greater difficulty completing tasks, forgetting what they are working on, and having difficulty carrying out multiple tasks in succession. The Plan/Organize subscale contains 13 items. This subscale is supposed to assess an individual's proficiency in planning current and future behaviors, as well as the ability to engage in efforts to complete these tasks. The Task Monitor subscale contains six items which are supposed to assess an individual's awareness of his/her performance on tasks that they have started. This subscale also intends to measure the extent to which an individual is able to realize mistakes or errors that he/she is making on a task. The Organization of Materials subscale contains eight items which are supposed to assess an individual's ability to organize his/her belongingness in an orderly manner.

BDI-II

The Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) is a 21 item self report of depressive symptomology for individuals age 13-80. Items on the BDI-II are intended to assess symptoms experienced in the two weeks prior to assessment, such as intense sadness, crying, or changes in sleep, appetite or sexual interest. Each item is a list of four statements of increasing severity. Items are on a four point scale ranging from 0 to 3, with a maximum score of 63. The BDI-II was developed to have clinical sensitivity for assessing depression criteria reported in the DSM-IV. Psychometric characteristics of the BDI-II were established using four outpatient psychiatric samples and a college student sample. The BDI-II manual reported that the BDI-II demonstrated good internal consistency (α = .92 for the outpatient samples and α = .93 for the college student sample), test-retest stability (α = .93 for a subset of outpatient samples) and good convergent and discriminant validity with respect to depression and anxiety respectively (Beck, Steer, & Brown, 1996). Cut score guidelines suggested in the manual are as follows: 0-13 (minimal range), 14-19 (mild range), 20-28 (moderate range), and 29-63 (severe range). However, the manual indicated that cut score thresholds may be raised or lowered to either reduce or increase the number of false positives. For example, lowering the cut score will detect the maximum number of individuals presenting with depressive symptoms.

Procedure

Following completion of data collection, each of the measures was scored as indicated in the administration manuals. Scoring was completed by trained graduate or advanced undergraduate students of psychology and supervised by a licensed clinical neuropsychologist. Scaled scores for each D-KEFS subtest (trail making, verbal fluency, design fluency, color-word interference, and card sorting) were scored separately according to the D-KEFS manual (Delis, Kaplan, & Kramer, 2001). BRIEF-A T-scores were calculated for each composite scale (GEC, BRI, MI, Inhibit, Shift, Emotional Control, Self-Monitor, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Task Monitor scales). A sum of all BDI-II items provided a total depressive symptom score. Age-corrected scores (i.e., scaled scores for the D-KEFS and T-scores for the BRIEF-A) were reported for descriptive analyses.

Prior to all analyses, all measures were examined for normality. For the BRIEF-A, the Infrequency, Negativity, and Inconsistency validity scales of the BRIEF-A were examined for elevations according the examiner’s manual. Following this criteria, no atypical participant profile was identified that necessitated exclusion from further analyses. An a priori power analysis was conducted to determine optimal sample size for Confirmatory Factor Analyses. This analysis was based on the largest model, which contained nine items and four factors. Following suggestions from Faul, Erdfelder, Lang, and Buchner (2007) five participants were suggested per parameter in structural equation analyses. Using a nine item model, with 9 loadings and 9 unique factor correlations on four factors, optimal sample size was estimated at 100-120.

Analyses

Relationship between Depressive Symptoms and Assessment (Hypothesis 1)

Multiple regression analyses were used to assess the relationship of depressive symptomology and gender differences with executive functioning. A hierarchical step-wise procedure was used, with full scale IQ from the WASI entered in the first step of the regression analyses to control for general intellectual ability. In the second step of analyses, scores on the BDI-II and gender were entered as the independent variables. Two sets of regressions were completed with seven tasks of the D-KEFS and nine subscales of the BRIEF-A as the dependent variables. In total 16 regressions were run.

Comparison of D-KEFS and BRIEF-A (Hypothesis 2)

To compare the D-KEFS and BRIEF-A, correlational analyses between composites of the BRIEF-A and subtests of the D-KEFS were completed. Significant correlations at the .05 level were used to indicate related executive functioning domains measured by both assessments.

Factor Structure of Executive Functioning (Hypothesis 3)

D-KEFS and BRIEF-A data were examined for normality prior to analysis. The constructs of executive functioning measured by each assessment were assessed using maximum likelihood confirmatory factor analysis (CFA) via LISREL 8 following suggestions by Bryant and Baxter (1997). All items were forced to have a single loading. X^2 values and five measures of goodness of fit (χ^2/df, RMSEA, SRMR, NNFI, and NCNI) were used to determine the goodness of fit for each of the a priori models for each measure. The factor structure of the 9 BRIEF-A subscales were examined using CFA, based on a priori hypotheses (see Hypothesis 3A). Four competing oblique models were compared in their adequacy of fit, based on previous literature (see Figures 2-5).

Three competing oblique models based on theoretical interpretations in the literature of executive functioning were tested using the five D-KEFS subtests (trail making, verbal fluency, design fluency, color word, and sorting tests). These models were based on a priori hypotheses (see Hypothesis 3A). Model 1 (see Figure 6) was a one-factor model. Model 2 (see Figure 7) was made of three factors (fluency, inhibition, and set-shifting) based on Miyake et al (2000). Model 3 (see Figure 8) was a five-factor model, with each of the five subtests constituting one factor, made up of the subtests' corresponding primary executive functioning measures.

CHAPTER FOUR

RESULTS

Descriptive Analyses

Descriptive data for the sample is presented in Table 2. WASI FSIQ was overall in the high average range (mean FSIQ SS = 110). The average BDI-II score was 7.51, indicating minimal depressive symptoms, and 5% of scores were in the moderate to severe range of depressive symptoms according to BDI-II manual guidelines (Beck, Steer, & Brown, 1996). The percentage of scores within the clinical range on BRIEF-A subscales (T scores of 65 and greater) are also presented in Table 2. Four to 13 percent of scores were in the clinical range in the sample, with the greatest problems reported in the Working Memory Index (13% in the clinical range). Scores on the D-KEFS ranged from the borderline to superior range, with the average score on all subtests within the average to high average range.

The analyses used in the current study, particularly SEM, are sensitive to skewed distributions and outliers, thus the data was examined for these issues. The distributions for all executive functioning variables were examined visually with respect to skewness or kurtosis, and all of the variables of interest appeared to be normally distributed based on visual inspection of scatterplot graphical representations. No outliers were found in the data.

All BRIEF protocols were screened for validity following missing item cutoffs

Table 2

Descriptive Statistics (N= 95)

Domain	Mean	Standard Deviation	Median	Range	% Clinically Elevated*
WASI FSIQ	110.85	10.27	111	84-137	NA
BDI-II (raw scores)	7.51	6.23	6	0-30	5
BRIEF-A (T scores)					
BRI	50.86	8.24	50	35-73	9
Inhibit	53.72	9.62	53	36-74	9
Shift	51.31	9.78	51	19-90	5
Emotional Control	49.66	8.48	47	38-69	7
Self-Monitor	49.12	9.08	47	37-76	6
MI	51.61	8.86	51	36-81	10
Initiate	51.34	8.81	50	37-76	7
Working Memory	53.51	9.40	53	39-86	13
Plan/Organize	50.89	7.63	49	38-73	4
Task Monitor	54.24	8.74	54	36-77	6
Organization Materials	48.32	11.08	47	7-78	8
D-KEFS (scaled scores)					
TMT Switching	10.39	1.97	11	2-13	NA
Letter Fluency	11.37	3.25	12	5-19	NA
Category Switching	12.21	3.06	12	5-16	NA
Design Fluency Switch	11.78	2.68	11	6-19	NA
CWI Inhibition	12.26	2.23	11	4-16	NA
CWI Switching	11.68	2.27	12	5-16	NA
CS Sort Recognition	9.95	2.66	10	3-16	NA

* BDI-II scores >20 considered in the moderate range; BRIEF-A clinically elevated scales have T scores ≥ 65

and evaluating the Inconsistency, Infrequency, and Negativity scales as suggested in the manual (BRIEF-A; Roth, Isquith & Gioia, 2005). All 95 BRIEF protocols were considered valid according to criteria suggested in the manual.

Relationship between Depressive Symptoms and Assessment (Hypothesis 1)

A series of hierarchical regression analyses were performed to assess the association of depression to executive functioning measures. For each analysis, FSIQ was entered in the first step; gender and depressive score were entered in the second step in a forward entry procedure.

Table 3 presents regressions related to the behavioral regulation subscales of the BRIEF-A. In the first step, IQ was not a significant predictor of problems on the Inhibit, Shift, Emotional Control, and Self-Monitor subscales ($p > .05$). Gender, entered in the second step, was a significant predictor for the Inhibit ($p < .05$) and Shift ($p < .01$) subscales, with males reporting greater problems in executive functioning than females (See Table 4). Depressive symptomology was a significant predictor in all BRIEF-A behavioral regulation models (Inhibit $p < .01$; Shift $p < .001$; Emotional Control $p < .01$; Self-Monitor $p < .05$). Higher levels of depressive symptomology were related to more reported problems on the Shift, Emotional Control, and Self-Monitor subscales. Lower levels of depressive symptomology were related to more reported problems on the Inhibit subscale. The final models in which gender and depression emerged as significant predictors involved the Inhibit and Shift subscales of the BRIEF-A. Gender and depressive symptomology accounted for 12% and 17% variance in executive functioning problems on these subscales, respectively. Final models which included only depressive

Table 3

Standardized Coefficients for BRIEF-A Behavioral Regulation Regression Models

	BRIEF-A EF Domain							
	Inhibit		Shift		Emotional Control		Self Monitor	
	β	t	β	t	β	t	β	t
FSIQ	-.02	-.20	-.11	-1.04	-.07	-.63	-.03	-.30
Gender	-.22	-2.05*	-.30	-2.89**	--	--	--	--
Depressive Symptomology	-.37	-3.44**	.40	3.83***	.36	3.50**	.28	2.62*
Adjusted R^2 for final model	.12		.17		.11		.06	

* p<.05; **p<.01; ***p<.001

Table 4

Significant Gender Differences in Self-Reported Executive Functioning

(male n= 17; female n=78*)*

Domain	Mean		Standard Deviation		% Clinically Elevated*	
BRIEF-A (T scores)	Males	Females	Males	Females	Males	Females
BRI						
Inhibit	56.65	52.67	11.12	9.46	24	10
Shift	55.00	50.24	12.99	8.85	10	4
MI						
Initiate	54.24	50.45	10.00	8.56	12	5

* Clinically elevated scales have T scores ≥ 65

symptoms as a significant predictor (i.e., Emotional Control and Self-Monitor) explained 11% and 6% of the variance, respectively.

Regressions related to the metacognition subscales of the BRIEF-A are presented in Table 5. In the first step, IQ was not a significant predictor of problems on the Initiate, Working Memory, Plan/Organize, Organization of Materials, and Task Monitor subscales ($p > .05$). Gender, entered in the second step, was a significant predictor only for the Initiate subscale ($\beta = -.23$; $p < .05$), with males reporting greater problems than females. Depressive symptomology was a significant predictor in all BRIEF-A metacognition models (Initiate $p < .001$; Working Memory $p < .001$; Plan/Organize $p < .001$; Organization of Materials $p <.01$; Task Monitor $p < .05$). The final model for the Initiate subscale which included both gender and depressive symptomology as predictors accounted for 24% of the variance in executive functioning problems. The final models for Working Memory and Plan/Organize subscales, with depressive symptomology as a significant predictor accounted for 15% and 13% of the variance in executive functioning problems, respectively. The final models for Organization of Materials and Task Monitor, with depressive symptomology as a significant predictor, accounted for 8% and 6% of the variance in executive functioning problems, respectively.

A summary of regression analyses predicting D-KEFS subtests is presented in Table 6. In the first step, FSIQ was a significant predictor of performance on Trail Making Test Switching ($p < .01$), Letter Fluency ($p < .001$), Category Switching ($p < .01$), Color Word Interference Switching ($p < .05$), and Card Sorting Sort Recognition ($p < .001$). Higher IQ level was associated with greater performance on these tasks. In the

Table 5

Standardized Coefficients for BRIEF-A Metacognition Regression Models

	BRIEF-A EF Domain									
	Initiate		Working Memory		Plan/Organize		Task Monitor		Organization of Materials	
	β	t	B	t	β	t	β	t	β	t
FSIQ	.03	.28	-.07	-.68	-.12	-1.14	.01	.06	-.06	-.53
Gender	-.23	-2.34*	--	--	--	--	--	--	--	--
Depressive Symptomology	.51	5.19***	.41	3.99***	.38	3.71***	.32	3.03**	.29	2.70*
Adjusted R^2	.24		.15		.13		.08		.06	

* p<.05; **p<.01; ***p<.001

Table 6

Standardized Coefficients for D-KEFS Regression Models

	D-KEFS Subtest													
	TMT Switching		Letter Fluency		Category Switch		Design Switching		CWI Inhibition		CWI Switching		CS Sort Recog.	
	β	t	β	t	β	t	β	t	β	t	β	t	β	T
FSIQ	.13	3.34**	.47	4.84***	.31	3.01**	.10	.93	.22	2.03*	.10	.90	.56	6.16***
Gender	.18	1.65	-.04	-.36	.14	1.37	.03	.28	.06	.52	.07	.61	.13	1.46
Depressive Symptomology	.12	1.09	.14	1.44	.03	.33	.06	.51	-.10	-.90	.01	.12	-.02	-.26
Adjusted R^2	.004		.21		.09		-.002		.04		-.002		.30	

* p<.05; **p<.01; ***p<.001

second step, gender and depressive symptomology were not significant in any of the D-KEFS models ($p > .05$). In the final models, 30% of the variance in performance on Card Sorting Sort Recognition and 21% of the variance in Verbal Fluency performance was accounted for by IQ. IQ accounted for 9 % of the variance in Category Switching performance and 6% of the variance in Color Word Interference Inhibition performance. Less than 1% of the variance was explained in the final models of Design Fluency Switching and Color Word Interference Switching, as none of the predictors were significant in these models (FSIQ, gender, or depressive symptomology).

Additional analyses were run for the subscales of the BRIEF-A in which both gender and depression symptomology were significant predictors to determine if there was a gender by depressive symptomology interaction effect on executive functioning. This interaction term, entered in the third step of the Inhibit, Initiate, and Shift models, was not significant ($p >.05$).

Comparison of D-KEFS and BRIEF-A (Hypothesis 2)

Correlations between BRIEF-A subscales and D-KEFS tasks are presented in Table 7. Moderate correlations ($r \geq .22$) were found between variables within the same measure (i.e., BRIEF or D-KEFS). With regard to the BRIEF-A, most correlations were significant at the .001 level, indicating that there was a strong relationship between the subscales of the BRIEF-A. The Trail Making Test Switching subtest was the least correlated among the D-KEFS tasks, with significant correlations found only for the Letter Fluency task and the CWI tasks (Inhibition and Inhibition/Switching).

Table 7

Bivariate Correlations between Executive Functioning Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.BRIEF Inhibit	1.0															
2.BRIEF Shift	.46***	1.0														
3.BRIEF Emotional Control	.41***	.47***	1.0													
4.BRIEF Self Monitor	.69***	.46***	.32**	1.0												
5.BRIEF Initiate	.52***	.45***	.47***	.44***	1.0											
6.BRIEF Working Memory	.64***	.58***	.34**	.54***	.59***	1.0										
7.BRIEF Plan/Org	.52***	.35**	.39***	.57***	.57***	.59***	1.0									
8.BRIEF Task Monitor	.55***	.50***	.41***	.62***	.58***	.61***	.56***	1.0								
9.BRIEF Org Materials Task	.47***	.33**	.22*	.45***	.55***	.51***	.58***	.66***	1.0							
10.D-KEFS TMT Switch	.08	-.04	-.05	-.00	.01	.13	.07	.09	.08	1.0						
11.D-KEFS Letter Fluency	.14	-.02	-.14	.17	.11	.07	.05	.11	.13	.25*	1.0					
12.D-KEFS Category Switch	.04	-.09	.03	-.04	-.03	.00	-.01	-.02	-.07	.05	.39***	1.0				
13.D-KEFS Design Switch	**.22***	.01	-.03	.15	.05	.09	.14	.17	.13	.22	.09	.25*	1.0			
14.D-KEFS CWI Inhibition	.17	-.11	-.18	.10	-.05	.04	.14	.01	-.07	.30**	.34**	.21*	.21*	1.0		
15.D-KEFS CWI Switch	.19	-.06	-.04	.06	-.09	.06	.14	.01	-.05	.39***	.27**	.11	.27**	.66***	1.0	
16.D-KEFS Sort Recognition	-.02	-.12	-.17	-.06	-.12	-.16	**-.23***	-.07	-.11	.11	.36***	.32**	.15	.29**	.16	1.0

* p<.05; **p<.01; ***p<.001

There were two significant correlations found between the BRIEF-A and D-KEFS. The Sort Recognition score from the D-KEFS was significantly correlated with the BRIEF-A Plan/Organize subscale ($r = -.23$, $p < .05$), indicating that better performance on this D-KEFS task was associated with fewer reported problems with planning and organizing as reported on the BRIEF-A. The Design Fluency Switching task from the D-KEFS was significantly related to the BRIEF-A Inhibit subscale ($r = .22$, $p < .05$). However, the positive correlation indicated that greater performance on the Design Fluency Switching Task was associated with greater reported problems in inhibition on the BRIEF-A. All other correlations between the BRIEF-A and D-KEFS were non-significant ($p > .05$).

Factor Structure of Executive Functioning (Hypothesis 3)

Analysis strategy

The factor structure of executive functioning was examined using confirmatory factor analysis via LISREL 8. As required by CFA, the user specified which items were expected to load on which factors, how these factors intercorrelate, and the relations among unique-error terms for the observed indicators. In this multidimensional model, items were forced to have a single loading, factors were standardized (i.e., variances fixed at 1), and unique errors were considered independent.

As previous research has indicated that multiple fit indices best determine model adequacy rather than sample size (Jackson, 2001), several fit indices were evaluated in the current study. Following suggestions by Hu and Bentler (1998), five different measures of goodness of fit were used to assess CFA models in the study: (1) the ratio of chi-square to degrees of freedom (χ^2/df), which decreases and approaches zero as the fit of the given model improves, (2) the root mean square error of approximation (RMSEA), (3) the standardized root mean square residual (SRMR), (4) the non-normed fit index (NNFI), and (5) the comparative fit index (CFI). According to Hu and Bentler, the RMSEA measure of relative fit should be no greater than .10 and ideally .05. They suggest that an SRMR value of less than .08 is indicative of good fit. Bentler and Bonett (1980) provide recommendations for evaluating NNFI and CFI values; specifically these measures of relative fit increase as the model improves are indicative of an adequate fit when greater than .90

Although conventional cutoff values indicated above are helpful in providing a minimum level of fit, in CFA the fit of a model is also interpreted relative to competing models (Ecklund-Johnson, Miller, & Sweet, 2004). CFA in the current study was used to evaluate the goodness-of-fit of four competing models for the BRIEF-A and three competing models for the D-KEFS. The results of these analyses are presented in Tables 8 and 9; the results are discussed in greater detail below.

BRIEF-A

CFA was used to compare four possible competing models using the BRIEF-A based on plausible theoretical interpretations of self-reported executive functioning. Model 1 was a single-factor model hypothesizing a global executive functioning factor. Model 2 was a two-factor model hypothesizing oblique behavioral regulation and metacognition domains. Model 3 was a three-factor model hypothesizing oblique metacognition, emotional regulation, and behavioral regulation domains. Model 4 was a four-factor model hypothesizing oblique internal metacognition, external metacognition, emotional regulation, and behavioral regulation domains.

The one-factor conceptualization of the nine subscales provides the worst fit and yields lower relative fit indices (See Table 8). Although SRMR was less than .08 and NNFI and CFI values were greater than .09, indicating good model fit, the RMSEA value for the one-factor model was greater than .10, suggesting a poor model fit. The relative fit indices improve with the two-factor model, but of the four models tested in the analyses, the three-factor model appears to have the best fit to the observed data. With this latter model, the majority of fit indices suggest an adequate fit (RMSEA < .10; SRMR < .08; NNFI and CFI >.90). Furthermore, while relative fit indices are comparable between the three-factor and four-factor models, RMSEA, NNFI, and CFI values show a slight increase from the three-factor to the four-factor model, indicating that the three-factor model provides the best fit to the observed data.

As expected given the large sample size, chi-square statistics for all four models were significant, although the chi-square value was the lowest for Models 3 and 4, as were the ratios of chi-square to degrees of freedom. Although the chi-square to degrees of freedom measure of relative fit was comparable between Models 3 and 4, as previously mentioned other measures of relative fit were preferable in the three-factor Model 3. Inspection of the inter-factor correlations from this three-factor CFA solution revealed that metacognition, emotional regulation, and behavioral regulation are highly intercorrelated (median $\Phi = 0.784$, 0.852, and 0.724; See Table 9).

Table 8

Goodness-of-Fit Statistics for BRIEF-A Factor Models

				Measures of Relative Fit				
Factor Model	*No. of Items*	χ^2	*df*	χ^2/df	*RMSEA*	*SRMR*	*NNFI*	*CFI*
1 global factor	9	62.698	27	2.3	0.104	0.058	0.944	0.958
2 oblique factors	9	55.077	26	2.1	0.094	0.055	0.952	0.966
3 oblique factors	**9**	**45.934**	**24**	**1.9**	**0.085**	**0.047**	**0.961**	**0.974**
4 oblique factors	9	39.703	21	1.9	0.086	0.043	0.962	0.978

Note: χ^2 = chi-square test statistic, df = degrees of freedom, χ^2/df = ratio of chi-square to degrees of freedom, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual goodness-of-fit index, NNFI = non-normed fit index, CFI= comparative fit index.

Table 9

Correlations between BRIEF-A Factors for Best Fitting Model: Three-Factor Model

	1	2	3
[1]Metacognition	1.000		
[2]Emotional Regulation	0.784	1.000	
[3]Behavioral Regulation	0.852	0.724	1.000

D-KEFS

Three competing models based on plausible theoretical interpretations involving seven D-KEFS tasks were compared using CFA. Model 1 was a single factor model (i.e., a global executive function factor). Model 2 was a three factor model, hypothesizing set-shifting, inhibition, and fluency factors. Model 3 was a five factor model, including motor executive function, verbal executive function, non-verbal executive function, inhibition/switching, and problem solving. The motor executive function, non-verbal executive function, and problem solving factors from Model 2 and the inhibition and fluency factors from Model 3 had single item loadings. For these factors, variance was set at .70, to account for 30% error.

Similar to the BRIEF-A the one-factor conceptualization of the seven D-KEFS tasks provides the worst fit and yields lower relative fit indices (See Table 10). All fit indices for the one-factor model were inadequate according to suggested set values (RMSEA >.10; SRMR >.08; NNFI <.90; CFI < .90). The relative fit indices do not improve with the two-factor model, as again none of the fit indices met suggested standards. The five-factor model provides the best fit to the data, with all measures of relative fit meeting criteria (RMSEA < .10; SRMR < .08; NNFI and CFI >.90). The chi-square statistic was the lowest for the five-factor model, as was the ratio of chi-square to degrees of freedom. Inspection of the inter-factor correlations from this five-factor CFA solution revealed that the “motor” factor and “inhibition/switching” factor were highly correlated (median $\Phi = 0.533$), as were the “problem solving” factor and “verbal” factor

Table 10

Goodness-of-Fit Statistics for D-KEFS Factor Models

				Measures of Relative Fit				
Factor Model	*No. of Items*	χ^2	*df*	χ^2/df	*RMSEA*	*SRMR*	*NNFI*	*CFI*
1 global factor	7	42.880	14	3.06	0.153	0.104	0.704	0.803
3 oblique factors	7	42.671	13	3.28	0.160	0.101	0.673	0.798
5 oblique factors	**7**	**14.832**	**9**	**1.65**	**0.079**	**0.054**	**0.907**	**0.960**

Note: χ^2 = chi-square test statistic, df = degrees of freedom, χ^2/df = ratio of chi-square to degrees of freedom, RMSEA = root mean square error of approximation, SRMR = standardized root mean square residual goodness-of-fit index, NNFI = non-normed fit index, CFI= comparative fit index.

Table 11

Correlations between D-KEFS Factors for Best Fitting Model: Five-Factor Model

	1	2	3	4	5
[1]Motor	1.000				
[2]Verbal	0.292	1.000			
[3]Non-verbal	0.320	0.331	1.000		
[4]Inhibition/Switching	0.533	0.385	0.363	1.000	
[5]Problem Solving	0.172	0.584	0.217	0.286	1.000

(median $\Phi = 0.554$; See Table 11). The motor factor and the problem solving factor were the most unrelated (median $\Phi = 0.172$).

CHAPTER FIVE

DISCUSSION

The findings in the current study highlight the complexity of the construct and the measurement of executive functioning. Analyses were completed to assess the overlap between general intellectual ability and the executive functions, the relationship of depressive symptomology with measures of executive functioning, and notable gender differences within and across measures in an undergraduate population. Two purported comprehensive assessments of executive functioning were directly compared to determine the nature of their relationship. Factor analyses were conducted to further elucidate the domain of executive functioning with respect to each measure. Results suggest that the executive functions are a multifaceted construct and reveal clear differences within two assessments of executive functions.

General Intellectual Functioning, Depressive Symptomology, and Gender

Historically, executive functions have been considered to be an aspect of general intellectual functioning, a subset of skills requiring higher-ordered thinking. The results of this study are consistent with this belief as well as previous research indicating that executive functions are related, but distinctly different from general cognitive abilities (Delis et al, 2007). WASI Full Scale IQ was significantly related to performance on several D-KEFS tasks: Trail Making Test Switching, Letter Fluency, Category Switching, Color-Word Interference Inhibition, and Card Sorting sort recognition score.

However, Full Scale IQ accounted for less than 10% of the variance in performance on TMT Switching, Category Switching, and CWI Inhibition, 21% of the variance in Letter Fluency performance and 30% of the variance in Card Sorting performance. Overall, these results indicate that approximately 70-90% of the performance on executive functioning tasks is not explained by general intellectual ability. Delis and colleagues (2007) reported that subsets of individuals showed discrepancies between their performance on an assessment of intellectual functioning and on executive functioning tasks from the D-KEFS. Taken together, these findings suggest that there is not an exact correlation between intellectual ability and executive functioning.

In addition to examining correlations between full scale IQ and performance on the D-KEFS, the current study also examined the relationship between intellectual ability and self-rated executive functioning as measured by the BRIEF-A. Interestingly, unlike the D-KEFS, general intellectual ability was not significantly related to any of the BRIEF-A subscales. There has been little research to date involving the comparison of a rating scale of executive functioning to intellectual ability. Vriezen and Pigott (2002) reported a significant correlation between Verbal IQ from the Wechsler Intelligence Scale for Children-Third Edition (WISC-III) and the BRIEF parent report version in a sample of children with traumatic brain injury. However, Rabin and colleagues (2006) reported a non-significant correlation between the BRIEF-A and estimated verbal IQ using the ANART in a mixed sample of older adults. The lack of a significant relationship found between IQ and the BRIEF-A further suggests that there are discrepancies between intellectual ability and executive functioning, particularly with regard to problems in the behavioral manifestations of executive functioning assessed on the BRIEF-A.

There were no gender differences in performance on any of the D-KEFS tasks; however, there were gender differences with regard to self-reported executive functioning. Specifically, men reported greater problems than women on the Inhibit, Shift, and Initiate scales. Although gender differences have been reported in child versions of the BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000; Guy, Isquith, & Gioia, 2004), studies involving older adults have reported non-significant gender effects (Rabin et al, 2006). It is possible that the younger sample of adults used in the current study displayed a pattern of responding that is more typically of adolescents, rather than older adults. This is not surprising given the evidence suggesting that the frontal lobes continue to develop into early adulthood (Casey, Giedd, & Thomas, 2000; Stuss, 1992), and the likelihood that there are lingering developmental differences between male and female brains. The finding that gender differences were specific to self-reported executive functioning rather than administered executive functioning tasks indicates that young adult males may be more likely to perceive problems that are not evident on laboratory based assessments.

There were also differences in the objective and subjective assessments with regard to their relationship to depressive symptomology. Depressive symptomology was significantly related to all subscales of the BRIEF-A, but not to any of the D-KEFS tasks. It is possible that this finding is an artifact of an over-reporting of symptoms across all self-report measures (i.e., BRIEF-A and BDI-2); however, this is unlikely given that depressive symptomology was negatively correlated with responses on the Inhibit scale of the BRIEF-A. While higher levels of depressive symptomology was related to greater problems in all executive functioning domains as measured by the BRIEF-A, with regard to the Inhibit scale greater reported problems in inhibition was related to fewer symptoms of depression. Given these findings, it is concluded that individuals who experience symptoms related to depression (e.g., intense sadness, crying, changes in sleep, appetite or sexual interest), also report having difficulty with some behavioral manifestations of executive functioning (e.g., shifting, emotional regulation, self-monitoring, initiating, working memory, planning and organizing, task monitoring, and organizing materials). The correlational design precludes the determination of a causal relationship, such as whether symptoms of depression lead to problems in executive functioning; however, there appears to be overlap between the behavior manifestations of executive functioning and depressive symptomology.

This finding is consistent with previous reports suggesting that there is a relationship between report of cognitive problems and depressive symptomology (Rabin et al, 2003; Roth, Isquith, & Gioia, 2005). In a sample of older adults with mild dementia, research has indicated that a heightened awareness of one's cognitive difficulties is related to greater depressive symptoms (Spitznagel, Tremont, Brown, & Gunstad, 2006). It is possible that a similar pattern is occurring in the sample of college students in the current study, where there is a notable discrepancy between the ability to perform on cognitive tasks and the experience of cognitive difficulties in daily life, with the latter more strongly associated with depressive symptoms.

Relationship between BRIEF-A and D-KEFS

A primary aim of the current study was to determine the degree of overlap or discrepancy between two comprehensive measures of executive functioning. The first set of analyses revealed discrepancies between the two measures in terms of their relationship to IQ, gender, and depressive symptomology. Specifically, although both measures were discrepant from general intellectual ability, the D-KEFS was partially correlated with IQ. In contrast, the BRIEF-A showed gender differences in the reporting of executive functioning problem behaviors and was correlated across all subscales with depressive symptomology.

Despite these discrepancies in the two measures of executive functioning, it was hypothesized that when compared directly to each other, specific domains of executive functioning between the measures would overlap. This hypothesis was based on the premise that the executive functions are composed of separate distinct abilities that can be identified across situations (and therefore also across different measurements). It was expected that the Shift subscale of the BRIEF-A would correlate with the switching tasks of the D-KEFS, the Inhibit subscale of the BRIEF-A would correlate with the CWI Inhibition task of the D-KEFS, and the Initiate subscale of the BRIEF-A would correlate with the Verbal Fluency tasks of the D-KEFS,

The data in the current study did not support the a priori exploratory hypotheses regarding these similar constructs across measures. Overall, highly significant correlations emerged among the BRIEF-A subscales and among the D-KEFS tasks, indicating a high inter-relatedness within each executive functioning measure but little overlap between measures. Only two significant correlations emerged between measures. Similar to Parrish and colleagues (2001) the BRIEF-A Plan/Organize subscale was related to the sort recognition score from the D-KEFS Card Sorting Test. The BRIEF-A Inhibit subscale was also related to the D-KEFS Design Fluency switching task.

Although the two EF measures were largely uncorrelated with each other, the significant correlations that were found between the two measures are worth further discussion. With regard to the relationship between the Plan/Organize subscale of the BRIEF-A and the Card Sorting Test from the D-KEFS, individuals who reported having fewer problems with their ability to plan and organize were able to identify more sorts on the card sorting task. This suggests that these individuals who view themselves as able to plan and organize themselves on a day to day basis are better able to perform on tasks that require planning and abstract thinking. In the literature, Barkley (2001) described how the ability to work through problems in one's head enables an individual to think about the hypothetical future. It is possible that those individuals who are able to problem solve are better able to mentally and physically organize.

The positive correlation that emerged between the Design Fluency switching task and the Inhibit scale was unexpected, as this result indicates that individuals who reported that they had *greater* problems inhibiting their behavior were able to generate *more* novel designs involving connecting filled and empty dots (a set-shifting task). It is possible that these individuals who view themselves as being mentally rigid are actually better able to perform on rule bound tasks. For example, the Design Fluency task requires individuals to use a set of rules: use four straight lines, make each line touch another line at a dot, make a different design in each square, and connect lines from a filled dot to an empty dot, etc. This task requires individuals to generate novel designs in the context of a given set of rules, thus individuals who may not be as good at inhibiting their responses are able to perform well on this task.

What Constructs are Measured by the D-KEFS and BRIEF-A?

A central goal to the current study was to closely examine the construct of executive functioning through measures of executive functioning. Results from the first set of analyses seem to indicate that the BRIEF-A and the D-KEFS are distinctly different measures with little overlap. Performance on the D-KEFS was more related to general intellectual ability than the BRIEF-A. In contrast, the BRIEF-A evidenced an association with a subjective rating scale of depressive symptomology and showed gender differences in problems in executive functioning. Correlational analyses between the two measures revealed that each was more closely related to itself than to the other. Though there was some overlap between measures, they each appear to measure a divergent construct.

Supposing that each measure is tapping into aspects of executive functioning, it is suspected that the two measures are assessing different components of executive functioning. This hypothesis is supported by the distinction made in the literature between “metacognitive executive functions” and emotional/motivation executive functions” (Ardila, 2008). Ardila suggested that traditional tests of executive functioning (i.e., laboratory based assessments) tap into the metacognitive executive functions or problem solving, planning, concept-formation, strategy development/implementation, working memory, and controlled attention. Under this premise, it is likely the emotional/motivational executive functions," which coordinate cognition and emotion/motivation are measured by a behavior rating scale like the BRIEF-A. The current study supports the idea that the D-KEFS is measuring performance-based, cognitive aspects of executive functioning and the BRIEF-A is assessing behavioral components of executive functioning that are based upon self-perspectives. Additional analyses were completed to more closely examine the factor structure of each measure separately.

BRIEF-A

A total of four factor analyses were completed involving the BRIEF-A based on previous research and theoretical assumptions. Four models were hypothesized, involved a one, two, three or four-factor solution to the BRIEF-A subscales. Confirmatory factor analyses revealed that the three-factor model provided the best fit to the data, similar to previous findings reported by Gioia and colleagues (2002) using the parent version of the child BRIEF. This model was composed of a Behavioral Regulation factor, an Emotional Regulation factor, and a Metacognition factor. This model is discrepant from the factor structure reported in the BRIEF-A manual, which suggests a two factor model composed of Behavioral Regulation and Metacognition (Roth, Isquith, & Gioia, 2005). It is possible that the three-factor model provides a more accurate conceptualization of executive functioning behavior with a younger adult sample used in the current study, more similar to findings reported for the child version of the BRIEF. However, it is important to note that although the three-factor solution provided the best fit to the data in the current sample, the three factors were highly correlated with each, as was the two-factor solution reported in the BRIEF-A manual. Factor analyses on the BRIEF-A consistently suggest models composed of different components of executive functioning; however, these models indicate that these factors are strongly related to one another. These findings lend support to the theory of executive functions as a domain of separate, but interrelated abilities.

D-KEFS

Confirmatory factor analyses were used to determine the latent factor structure of the seven D-KEFS tasks. While previous studies with performance-based measures of executive functioning have found three-factor models (e.g., Miyake et al, 2000), the five-factor oblique model provided the best fit to the data. These five factors were termed “motor executive functioning,” “verbal executive functioning,” “non-verbal executive functioning,” “inhibition/switching,” and “problem solving.” These factors were most similar to the five-factor model reported by Pineda and Merchan (2003). Their final model included a factor for WCST variables, Stroop naming and reading, Stroop time, Trail Making Test A and B, and Verbal Fluency. Like the five-factor model using the D-KEFS tasks, this solution supported a separate factor per task model, with the exception of the Stroop task which comprised two separate factors.

Additionally, examination of the correlations between the factors in the five-factor D-KEFS solution revealed that the factors were less related than were the three-factor BRIEF-A model. The strongest correlations were between the problem solving and inhibition/switching factors and the problem solving and verbal executive functioning factors. That some tasks are more correlated than others suggests that these tasks might be invoking similar frontal pathways in the brain or involving associated areas in the brain. For example, there is a large body of research citing the involvement of the left dorsolateral prefrontal cortex in verbal fluency tasks (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Lezak, 1982; Malloy, Cohen, Jenkins, & Paul, 2006; Veiel, 1997); it is possible that the left dorsolateral prefrontal cortex might also be activated during the Card Sorting Test. However, these conclusions are speculative in the absence of neuroimaging data.

Domain of EF: Unified or Separate?

The current study sought to provide further insight into the debate on whether the executive functions constitute a unified domain of abilities or whether they are best understood as separate and distinct skills. This study provides overwhelming evidence in favor of a multi-dimensional conceptualization of executive functioning. First and foremost, two assessments designed to measure aspects of executive functioning were found to be largely unrelated to each other. When several plausible models (including both single and multi-factor models) involving both of these measures were examined, it was determined that multi-factor models provided the best fit. These findings provide support for the assertion that assessments of executive functioning should consider the executive functions to be a multidimensional construct (Gioia, 2002).

The best fitting model for each executive functioning assessment highlighted unique components of executive functioning. The BRIEF-A three-factor model suggested a Metacognition, Emotional Regulation, and Behavioral Regulation factor whereas the D-KEFS five-factor solution recommended a Motor Executive Function, Verbal Executive Function, Non-verbal Executive Function, Inhibition/Switching, and Problem Solving factor. As previously mentioned, one argument might be that one or both of these assessments is not measuring “pure” executive functioning. However, it is also possible that each assessment is tapping into different aspects of executive functioning. For example, the BRIEF-A was designed as a measure of the behavioral aspects of executive functioning that can be observed in real world settings, on a day to day basis. In contrast, the D-KEFS attempts to assess individuals’ ability to perform on tasks that are thought to require executive functioning.

Theoretically, one would assume that an individual’s performance on a given task would correspond to their ability to carry out tasks of daily living involving executive functioning. However, this study was interested in individuals’ ratings or self-perceptions of their executive functioning. Given the low correlations between the objective and subjective measures of executive functioning examined in this study, it is concluded that there are discrepancies between how people view their problems in executive functioning and their actual performance on tasks.

Limitations of the Study and Directions for Future Research

There were several limitations to the current study that need to be acknowledged. First, there were restrictions posed by the sample used in the study. The sample size limited the ability to conduct factor analyses combining the tasks of the D-KEFS and subscales of the BRIEF-A. Though a central finding in the study was that the D-KEFS and the BRIEF-A represented two distinct measures of executive functioning with little overlap, future studies might confirm this finding through use of factor analyses with both of these measures. Additionally, the sample used in the current study was restricted to individuals aged 18-24, with an average of 12 years of education. The majority of the sample was female (82%) and Caucasian (76%). Further studies might include a wider age, education, gender, and ethnicity range. These limitations are particularly important given some of the issues discussed with regard to gender and the factor structure of the BRIEF-A in younger adult and older adult samples. In particular, the findings related to gender and factor structures of the assessments should be replicated in additional samples.

The current study was limited to the use of two comprehensive measures of executive functioning (i.e., the D-KEFS and the BRIEF-A). However, as presented earlier, there are numerous other stand-alone performance-based neuropsychological assessments that propose to measure executive functioning (e.g., Wisconsin Card Sorting Test). Future studies might include these other neuropsychology measures to determine the amount of overlap or discrepancy between these measures and the measures used in the current study.

The BDI-2 was used to determine the presence of depressive symptomology; however, the ratings obtained in the study using this assessment were not intended as a diagnostic tool for depression. Although the sample was restricted to individuals without severe psychopathology, future research might collect information from objective sources regarding diagnostic criteria of depression or include individuals who have met criteria for major depression. It is possible that the rating scale of depressive symptomology used in the current study (i.e., the BDI-2) might have limited the ability to detect higher levels of depressive symptoms that might have affected performance on the D-KEFS. Given this limitation, it cannot be ruled out that the correlation found between the BDI-2 and the BRIEF-A may have been an artifact of the subjective nature of the two assessments. To further elucidate the relationship between executive functioning assessment and depressive symptomology, future research might include the observer rating of the BRIEF-A to assess objective rating of executive functioning.

Implications

The current study makes several important contributions to the literature. First, it presents additional evidence for the viewpoint of executive functioning as a multi-faceted construct. Under this framework, executive functioning should be considered as a related but distinct aspect of general intellectual functioning. Within the larger domain of executive functioning are distinct and separate abilities that can be adequately assessed using laboratory based assessments and rating scales. There remain discrepancies between these assessments, as well as across performance-based assessments of executive functioning. Though the D-KEFS proposes to measure comprehensive executive functioning, it is important to note that each task within this larger assessment is not measuring the same ability. As performances across tasks are largely unrelated, patients may show a wide range of variability within this one assessment and within the domain of executive functioning.

Furthermore, traditional performance-based laboratory measurements of executive functioning may fail to capture all aspects of executive functioning. The addition of a subjective rating scale adds a layer to the assessment of executive functioning by measuring an individual's perception of their difficulty within executive functioning areas. The identification of both objective and subjective problems can better inform clinicians, family members, researchers, and educators about the functioning of a patient who undergoes neuropsychological assessment.

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